UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL, 1939.

A

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

At the beginning of 1939 the prospect of a period of general progress for the Department of Agriculture and Horticulture under stabilised conditions appeared on the point of fulfilment. The Campden Research Station, under the directorship of Mr. Hirst, had already been working with marked success in close association with the Department of Scientific and Industrial Research from the time the latter became the channel of the Government grant-in-aid in 1935 and no cause for serious anxiety as to the future has arisen. At the Long Ashton Research Station and the Berkeley Square Agricultural Advisory Centre—the two other constituent centres of the University Department—the position, on the other hand, had grown increasingly difficult over that period, mainly owing to the inadequacy of the grants-in-aid for the maintenance of their work received through the Ministry of Agriculture and Fisheries. A more promising outlook developed in 1938 and it became possible to state in the Annual Report for that year that in consequence of a general survey of the financial position grant increases were likely. At that time the Ministry and the Agricultural Research Council had under consideration estimates, prepared at their request, for a block grant to the Long Ashton Station covering a period of four years beginning with the academic year 1938–39, in addition to proposals for a substantial increase in the annual grant for the general agricultural and horticultural advisory work for the Bristol Provincial Advisory Centre.

However, as was the case exactly a quarter of a century ago, when the research and advisory schemes had recently been established at Long Ashton in association with the University of Bristol and the preliminaries as regards staff, buildings and equipment had been completed and all was in readiness for a forward move, the over-riding claims of a national emergency have enforced a radical change of outlook and drastic modifications in plans. Attention has had to be diverted from long-range research to practicable war-time investigations of an *ad hoc* character and advisory work has been directed mainly towards problems of food production and conservation of immediate urgency under war conditions. Although the actual outbreak of war did not occur

until two-thirds of the year had elapsed, the uncertainty of the international situation and the sense of insecurity as to the course of developments subsequent to the German invasion of Czecho-Slovakia in the spring have affected in one way or another the activities of every section of the Department throughout the greater part of 1939.

Thus the present Annual Report, while including some contributions on results of long-distance and other normal work started prior to 1939, inevitably reflects in many respects the general unsettlement of the times and represents a period of adaptation of the Department to war conditions of working. For reasons of economy individual contributions have been presented as briefly as their nature permits. The Report of the work of the Campden Station has been issued separately by that Station in accordance with recent practice.

In these circumstances the administrative side at Long Ashton and Berkeley Square has been conducted under conditions of exceptional difficulty. The four-year-period block grant scheme relating to the research grant for Long Ashton has had to be deferred indefinitely, a decision not taken until late in the year. Earlier in the year there had been a series of discussions and communications between the University and the Ministry with regard to details in the estimates under consideration for the period grants and it had seemed that agreement between the two bodies as to the approximate totals of the annual grants over that period had been reached. Meanwhile, the Ministry informed the Station that (*a*) the research grant for the year would be maintained on the basis of that for the previous academic year 1937–38 as an interim arrangement, and (*b*) it was intended to make the new period-grant rate retrospective to cover the academic year 1938–39, when Treasury approval had been secured. That prospective new grant represented a substantial increase in rate on that of the previous year. In the end, however, the outbreak of war—the cause of the suspension of the four-year grant plan—entailed a further grant revision and the reduction of the greater part of the prospective increment in question.

Although the grant for the Advisory Centre for the corresponding period had been settled earlier, the total grant available was known to be insufficient—even with the additional supplementary revenue from other sources—to cover the cost of the work.

For both Centres, therefore, faced with the alternatives of a continuation of the sequence of losses on the year's accounts or a drastic cutting down of the programme of work, it was decided to

impose rigid economies wherever practicable and to ration strictly the expenditure on travelling for all members of staff. Even so, substantial losses on both advisory and research accounts would have been incurred, had the Ministry not secured special supplementary grants to meet those deficits.

In addition to the financial uncertainties of the year and the planning of emergency programmes of work for the Department in readiness for war conditions, serious consideration has had to be given to the staffing questions involved. On the one hand, the Ministry and the Agricultural Research Council have decided that, in view of the vital importance of ensuring a great increase in the production of agricultural and horticultural food crops in this country, it is imperative that the research and advisory services concerned should be maintained, and in certain directions strengthened, as far as the calls of the essential National Services permit. The need for research workers and advisers of suitable training and experience has become greater than before and on the advisory side in particular a much larger call on their services is anticipated as the farmers' problems associated with the newly-ploughed acreage develop during the coming year. On the other hand, the present man-power at the Research and Advisory Centres has already been depleted since the outbreak of war by the calls of the Services and, as time goes on, further inroads will certainly have to be faced. Unless a more critical state of national emergency arises, it is expected that under the arrangements made during the course of the year a sufficient technical staff can be retained in each section of the Department to enable the research and advisory services to be maintained as efficient working units.

The situation, with both research and advisory staffs engaged almost entirely on programmes of work adapted to war-time requirements, naturally involves a closer degree of touch than usual with the Ministry and the Agricultural Research Council, to give effect to the general policy of those bodies and its changing features imposed by the course of the war. In more normal circumstances the activities of individual members of the staff of the Department are left under the direct control of the Agricultural Committee of the University, once the proposed programmes of work for the year have been approved by the Ministry. For the duration of the war, however, this arrangement is to be relaxed at the request of the Ministry. In order to make the fullest possible use of the technical knowledge and experience of the members of the staff as occasion arises the Ministry itself can now call upon individual workers to assist it in the preparation, organisation and conduct of schemes of war-time urgency and the production of publications for which

they possess specialist qualifications. Already, as the following pages show, help of this kind is being given by several of the staff.

BERKELEY SQUARE ADVISORY CENTRE.

Staff.

No new appointments have been made during the course of the year. Staff changes have been few. Mr. W. R. Muir, B.Sc., Research Assistant in Agricultural Chemistry, resigned his post at the end of March in order to take up an appointment as Biochemist at the Royal College of Veterinary Surgeons.

Mr. R. A. Pullin, M.R.A.C., N.D.A., one of the Field Officers appointed in 1938 under the Lime and Phosphate Deficiency Survey, has resigned his post and left in October, 1939.

General.

In the Annual Report for 1938 reference was made to the provision by the Ministry of Agriculture for a Lime and Phosphate Deficiency Soil Survey in the counties of the Bristol Province. The details of this scheme were given in that Report. The scheme has been in active operation since October, 1938, and extremely good progress has been made. It has already proved its value under war conditions, particularly with reference to soil questions which have arisen under the " ploughing-up " campaign in the area concerned. Both farmers and landowners have co-operated heartily with those responsible for the administration of the work under the scheme and have shown much keenness in the results, which have proved valuable for their guidance in the necessary treatment of the land concerned.

The British Basic Slag Corporation Limited has renewed its grant for the conjoint experiments with the Centre on the lime value of low-grade and high-grade basic slags on acid grassland.

The renewal of the grant for another year by the Chilean Nitrate Corporation Limited has also been notified. In this instance the investigations are concerned with an " exact " experiment on the manuring of grassland, this being in progress at the Research Station, Long Ashton.

The investigations on the nutritive value of hay, undertaken on behalf of the Bath and West and Southern Counties Agricultural

Society, have been completed. A detailed account of the work and results appears in the report published in the Journal of the Bath and West Society, Vol. XIV, 1939–40. The grant made by the Society towards this investigation has now been discontinued.

The Ministry of Agriculture and Fisheries has requested Dr. C. V. Dawe, the Advisory Agricultural Economist at the Centre, to act during the war as an Intelligence Officer for the Bristol Province to provide the Ministry with information concerning the trend in prices of agricultural commodities and the costs of production of such commodities in the area served by the Berkeley Square Advisory Centre. Dr. Dawe's services have been made available to the Ministry for that purpose and for any other purposes relating to Agricultural Economics which may arise from time to time during the course of the war.

At the request of the Ministry of Information, Mr. A. W. Ling, Agricultural Officer in charge of the Centre and Adviser in Agricultural Chemistry for the Bristol Province, has been authorised to collaborate with the Regional Director of the Ministry of Information in the provision of information for publication relating to matters of agricultural and horticultural interest in the Province. Through him the whole of the Department of Agriculture and Horticulture has been brought into direct contact with the regional activities of the Ministry and is providing it regularly with articles of current interest for publication in the Press and with announcements for broadcasting by the British Broadcasting Corporation.

LONG ASHTON RESEARCH STATION.

Staff.

The unsettled conditions prevailing during the year and the ultimate suspension of the period-block-grant scheme have been responsible for the comparatively few additions made to the staff during the year. In the last Annual Report it was foreshadowed that a number of new posts might be created to meet the needs of certain branches of the work of the Station for which the present available staff was numerically inadequate. The strengthening of the staff in this manner has had to be deferred indefinitely.

Two short-term appointments have been made under a Special Investigation grant provided by the Agricultural Research Council for research on copper and sulphur fungicides. Mr. R. L. Wain, M.Sc., Ph.D. (Sheffield), A.I.C., from the Chemical Department of the South-Eastern Agricultural College, Wye, Kent, has been

appointed as Research Chemist for these investigations, while Mr. E. H. Wilkinson, B.Sc. (Birmingham), previously a post-graduate worker in the Plant Pathology Section at the Station, has been placed in charge of the mycological and biological sides of the investigations. Both these workers are attached to the Plant Pathology Section of the staff and the investigation is under the general supervision of Dr. H. Martin and Mr. R. W. Marsh, the senior members of that Section.

Temporary provision for the extension of the work of the Fruit Products Section by an interim grant from the Ministry of Agriculture and Fisheries was announced in the Annual Report for 1938. It was stated at the same time that the financial responsibility for the maintainance of this extension might be transferred to the Department of Scientific and Industrial Research. The character of the work, being associated with crop utilisation rather than crop production and akin to that of some of the investigations on fruit already in progress under the Food Investigation Board of that Department, places it more within the province of that body than of the Ministry of Agriculture and Fisheries. The suggested transfer was approved and from the beginning of April, 1939, the cost of the extension of the work has been borne by the Department.

Of the two new appointments made possible by that grant that of Mr. Hugh Dickson, D.Sc. (Lond.), as Microbiologist in the autumn of 1938 has already been reported. Since the outbreak of war his services have not been available owing to army duty: consequently staff rearrangements within this Section have been made. Under these Mr. V. E. Sills, B.Sc. (Birm.), hitherto occupied with other work in the Section, has taken over the microbiological work associated with the specific investigations covered by the grant.

At the end of July 1939, two members of the staff of long standing, Messrs. H. P. Hutchinson, B.Sc. (Lond.), Willow Research and Advisory Officer, and Mr. W. H. Neild, the Recording Officer for Pot Experiments and Fruit Storage, terminated their official positions at the Station, both having reached the age for retirement.

Mr. Hutchinson joined the staff of the Station in 1922, when the Ministry of Agriculture and Fisheries initiated a scheme to assist growers of willows and osiers for the making of basketware, by the provision of facilities for research and technical advice on the culture of that class of willow. The Long Ashton Station was selected as the most appropriate centre for the scheme owing to its location in Somerset, the county with the largest acreage of that crop. With his previous experience in the subject

and his acquaintance with willow growers throughout the country, Mr. Hutchinson was the obvious expert for the post. He quickly became even more widely known to those associated with the industry by the interesting and attractive series of exhibits illustrating his work which were prepared and staged by him each year at the Shows of the Royal, the Bath and West, and other leading Agricultural Societies. In due course he extended the range of his work to include the cricket-bat willow also and his recent investigations on the methods of culture of that tree and their influence on the quality of the timber for cricket-bat usage will be familiar to readers of the recent Annual Reports of this Station. The measure of success which has attended his work can be estimated by the numerous appreciative letters received since his retirement.

With the retirement of Mr. Neild the last remaining direct staff link between the present fruit research stations in this country and the original centre of the kind, the Woburn Experimental Fruit Farm, is now broken. The older generation of fruit growers can recall the keen interest and vigorous controversies aroused at the time by the investigations at Woburn under the auspices of the Duke of Bedford and the late Mr. Spencer U. Pickering. Those having had occasion to visit the Woburn Farm during its existence will need no reminder of the enthusiasm and energy of its Manager, Mr. Neild. On the closing down of the work at Woburn in 1920 he accepted the post at the Long Ashton Station which he now relinquishes. During the course of his tenure of it his circle of friends and acquaintances in the horticultural world has still further widened, and there can be few who have visited Long Ashton or have inspected the Station's exhibits at the Imperial Fruit Shows, the Chelsea Shows of the Royal Horticultural Society, the Brewers' Exhibition and the leading Agricultural Societies' Shows who will not miss his cheery, live and untiring personality. As an indication of the value of his services in the internal work of the Station it is unnecessary to amplify the brief statement that their extent can be gauged by the important developments of the investigations of Dr. Wallace on the nutrition of fruit trees and the factors affecting fruit quality : these were founded on the pot culture experiments and the fruit storage tests carried out under his watchful daily care.

The coincidence of the retirement by superannuation of these two members of the staff who have taken a very active share in the corporate social side of the life of the Station will be heavily felt. In their respective ways each had been a great asset. They carry with them the best wishes of the staff for happiness and good health in the years remaining to them : and with those wishes and

appreciation of their services the Agricultural Committee of the University and the respective industries for which they have given their life-work are also associated.

Several members of the staff are rendering special individual service to the Ministry of Agriculture and Fisheries and other public bodies under war conditions. Dr. Wallace, the Deputy Director of the Station, has been appointed by the Minister of Agriculture to serve on a Scientific Advisory Panel in connection with the Food Production Campaign and has also been closely associated with the preparation of the Ministry's Special Bulletin on Vegetable Production. Dr. Kearns is co-operating with the Ministry in a scheme for the organisation of a spraying campaign to control diseases and pests of crops for the cropping season of 1940. Miss Crang has been engaged conjointly with officials of the Ministry and the National Federation of Women's Institutes on the organisation of plans to facilitate the preservation of home-grown fruit and vegetables by housewives. Mr. Hobbis and Mr. Locke have taken active parts in the Food Production campaign in the Bristol area among allotment holders and private gardeners.

Owing to the temporary closing of the laboratories at the Imperial College, London, consequent on the outbreak of war, laboratory accommodation has been provided at the Station for Professor A. C. Chibnall, D.Sc., F.R.S., and two of his assistants for the completion of special investigations on which they were engaged at that time at the College.

Buildings and Land.

There is little to report as regards building developments at the Station during 1939. Necessarily the general situation has made it necessary to abandon for the time being any material additions or alterations to the existing premises.

The condition of the various buildings at the Station and the housing property associated with it has been the cause of some anxiety during the past two years, since the general financial position of the Department has made it difficult to provide adequate funds to maintain the property in a proper state of repair. During the course of 1938 a detailed survey of the whole of the property was undertaken, including the farm buildings, roads and fences, in addition to the other buildings already mentioned. Estimates of the cost of the various repairs and renewals required were obtained and the total sum involved was so great that it was obvious that much of the work would have to be deferred until the more urgent

needs had been met. The course of events during 1939 made it impossible to put in hand any extensive maintenance work, even in the more urgent cases. In the meantime the position has grown still worse and it has become imperative to make arrangements for the most urgent cases to be dealt with without further delay. The attention of the Ministry of Agriculture has been drawn to the position and the proposals for a property repairs grant have been formulated.

Parts of the cider house premises have been adapted to serve for shelter purposes in the event of air raids. The changes required thereby have added still further to the state of congestion in that building referred to in the Report for 1938. This curtailment of space has been felt the more seriously since, owing to the abnormally large crop of cider fruit in the autumn of 1939, the quantity of cider made was greater than in other recent years.

In view of the increased extent to which tractors and other power cultivators are now used for plantations purposes, it has been found desirable to make provision at the Station for a repairs workshop on the premises. Consequently a section of the main block of the farm buildings has been adapted for this purpose and the necessary alterations have been carried out and fittings installed. This has been done under the supervision of Dr. H. G. H. Kearns, who has taken charge of the cultivators, spraying machines and other equipment of that order, in addition to the normal duties associated with his post of Research Entomologist. This re-arrangement has resulted in a considerable saving of time and expenditure.

Reference was made in the Annual Report for 1938 to the change of policy in respect of the field experimental work in the plantations. The revised policy has for its objective the gradual replacement of the fruit plots showing the greatest losses by others laid out with greater regard to costs and returns. The change in the international situation, however, has necessitated a temporary variation in that policy. While several of the unprofitable plots have been grubbed, the vacant land has not been replanted with fruit as intended, and will be cropped with vegetables instead for the time being. It is considered that during a national emergency this is the most useful purpose to which the land can be applied, as long as immediate increased food production is imperative. New fruit plantings during the course of the year have been restricted to soft fruits required in connection with the special pest and disease control investigations in progress at the Station.

The remainder of the farm land at the Station not included in the plantations earlier is being farmed under the charge of Mr. A. W.

Ling, the Chief Agricultural Advisory Officer at the Berkeley Square Centre. It consists mainly of hillside pasture.

General.

Annual Field Day. This function took place at the Station on Thursday, May 4th. It differed from its predecessors in recent years in having no Prize-giving Ceremony and no formal speech-making. This change was due to the fact that the Cider Competitions, which have been a feature of the work in the Cider House for many years, were discontinued during the cider-making season 1938–39. The dropping of the Competition Scheme has caused some degree of disappointment among the many cider-makers and others who are specially interested in that side of the work of the Station. It was decided upon only after very careful consideration had been given to the general position of the work of the Cider and Fruit Products section. It was felt that the Competitions had served their main purpose in their existing form and that their continuance was not justified on account of the heavy call on the time of the cider staff associated with them at the expense of other more urgent work.

In place of the Prize-giving Ceremony a special meeting of Members and Associates of the National Fruit and Cider Institute was held during the course of the afternoon. This afforded an opportunity for a discussion of a number of matters of immediate interest to the cider industry.

The sampling of ciders made during the season as a part of the Station's programme of cider experiments was arranged, and thus the function still retained its characteristic feature as "Cider Tasting" Day.

Among the exhibits staged in the Cider House was one contributed by the Ministry of Agriculture and Fisheries relating primarily to the various National Mark Schemes of the Ministry. As usual, this feature attracted much attention and created a good deal of interest.

During the day demonstrations in the Fruit Plantations were continuously in progress and several types of small-power cultivators and other machines were on view under working conditions.

Fruit Products Conference. On March 23rd a Conference on Pure Fruit Juices and Syrups, in conjunction with a Demonstration of Fruit Products, was held at the Station. The four papers read

at the Conference were available in time for publication in the Annual Report for 1938. There was a large attendance, fully representative of the various interests concerned and drawn from all parts of the country.

Visitors. During the first eight months of the year many individual visitors from Great Britain and overseas were received at the Station. Since the outbreak of war the number of visitors has been considerably reduced. In addition to individual visitors many organised parties have been received, including the following: -

Bishop Road School Gardening Class.
Reading University Students.
Bristol University Botanical Society.
Fishponds Branch of the Townswomen's Guild.
Rhodesian Scholars.
Somerset Headmasters' Study Circle.
Ladies of Bristol Branch of British Legion.
Bristol Branch of Auctioneers' Institute.
Bristol Co-operative Society's Horticultural Association.
Cardiff Small Holdings and Allotments Committee.
Clifton College Scientific Society.
Studley College Students.
National Co-operative Men's Guild.
Empire Fruits Conference.
Transport and General Workers' Union—Educational and Social Council.
Bristol Schoolmasters' Association.
Royal Agricultural College Fruit and Vegetable Preservation Course Students.
Society of Yorkshiremen.
Bristol Branch of Institute of Handicraft Teachers.
Somerset Beekeepers' Association.
Canadian Schoolboys.
Knowle Gardens Guild.

Show Exhibits. Exhibits have been staged at the following shows during the course of the year :—

Devon County Show, Axminster.
Oxford County Show, Oxford.
Asparagus Show, Evesham.
Bath and West Show, Bridgwater.
Three Counties Show, Worcester.
Cheltenham Floral Fete, Cheltenham.
Royal Agricultural Show, Windsor.
Gillingham and Shaftesbury Show, Shaftesbury.
Melplash Agricultural Show, Bridport.

In some cases these have been conjoint efforts with the County Agricultural Education staffs concerned. The Imperial Fruit Show, arranged to take place in London in November, had to be cancelled owing to the war : otherwise the Show list followed the usual lines.

Hop Virus Disease Investigations. A Conference on Virus Diseases of Hops was held at Maidstone in January and was attended by representatives of the Long Ashton Station. As a result of the Conference a scheme of research on virus diseases of hops was organised and the necessary financial support obtained from growers. Under this scheme the work is being carried out conjointly by the East Malling and Long Ashton Research Stations and the South-Eastern Agricultural College.

Research Students and Voluntary Workers. The number of post-graduate workers at the Station during the year has been less than during other recent years on account of the unsettled international situation. The list of such workers is as follows :— Mr. Y. V. Rao, M.Sc., Mr. A. F. Parker-Rhodes, B.A., Dip.Agric., Mr. D. M. Behura, B.Sc., Mr. M. I. Shah, M.Sc., and Mr. S. H. Bennett, B.Sc. Of these Mr. Y. V. Rao, M.Sc., has been awarded the degree of Ph.D. by the University of Bristol and has now returned to India to take up an appointment in that country. Mr. D. M. Behura, B.Sc., after one year's work returned to India for the Long Vacation and was unable to get back to Long Ashton to resume his studies.

Acknowledgments.

The work of the Department has been greatly facilitated by the cordial co-operation and generous support of the many farmers, fruit growers, market gardeners, cider makers and others directly associated with its varied and widespread activities. A corresponding acknowledgment is due also to those societies, private firms and public companies representative of the allied industries and commercial interests which have given valuable help in one form or another.

Equally appreciated have been the contacts and friendly working relations with the staffs of other University Departments, Research Stations and Advisory Centres, of the County Councils and other public bodies throughout the country coming within the range of the work in progress, and of Government Departments in this country and overseas with which official links exist or liaison has been established.

In a period so full of anxiety as that of the past few years the Agricultural Committee of the Department and its Sub-Committees have had the unenviable task of deciding between the conflicting claims of constantly expanding work, with its ever-increasing

expenditure, and an income for maintenance which has been relatively inelastic. After the apparent solution of their main financial questions outstanding in the early months of 1939, the close of the year has found them faced with problems of even more complexity owing to the war.

For their continued efforts to maintain its work on a satisfactory basis and for their close personal interest in its well-being the whole of the staff of the Department and all affected by its activities owe much to them, both collectively and individually.

It is thus with a sense of heavy loss that the death of one of its senior and most active members, the late Mr. F. Paget Norbury, J.P., shortly after the end of this year, is announced. From the time of his appointment to the Agricultural Committee in 1924 he took a leading part both in the work of that body and also of its standing Sub-Committees for Finance and Business and for the Campden Station. He was one of the representatives of the Worcestershire County Council on the Governing Body of the National Fruit and Cider Institute and became its Vice-Chairman in 1933, an office which he retained until his death. Recognised as an outstanding figure in contemporary English commercial fruit-growing and an agriculturist of wide knowledge and experience, he had also close touch with matters of agricultural education and public administration in his capacity as Chairman of the Agricultural Education Committee of the County Council of his native county of Worcester. With this range of experience and his progressive outlook he was exceptionally well equipped for the positions held by him in relation to the Department. His helpful advice and sound judgment will be greatly missed both in Committee and by individual members of the staff, for whose work he was always ready to give the benefit of his own knowledge and experience.

To the staff in general, with their work hampered in many ways by the unsettling conditions and necessary economies, a special tribute for their support throughout the year must be paid.

THE EFFECT OF PRUNING FOR TREE SHAPE UPON THE YIELD OF APPLES.

By T. SWARBRICK.

Introduction.

The present emergency brings into prominence the importance of obtaining high yields even at the expense of slightly reduced quality. The main purpose of this brief report of the major pruning trial in progress at Long Ashton is to emphasize the importance of light pruning in facilitating high yields of apples. At this time when labour is increasingly difficult to obtain and must be employed so as to yield its maximum result, the question of cutting out some of the winter pruning, particularly in the more mature trees, and of reducing it in the case of young trees, deserves very serious consideration. The cumulative experience of all workers in this subject and the data now presented show that under present conditions labour can be saved and crops increased over the next few years by adopting suitable pruning methods without serious detriment to future cropping.

The data presented in this paper have been obtained from the large scale experiment now in progress at Long Ashton where a number of different apple varieties are receiving different pruning treatments intended to give the trees different forms or shapes. A progress report was published in the Annual Report of the Research Station for 1937. (1). The varieties are Cox, Worcester, Allington, Early Victoria, and King Edward, and the pruning treatments are as follows :—

Treatment. 1. Regulated.
2. Open Centre, Winter pruned only.
3. ,, ,, Summer and Winter pruned.
4. Modified Leader, Winter pruned only.
5. ,, ,, Summer and Winter pruned.

Presentation of Results.

With the exception of King Edward, for which the crop was exceedingly light, 1939 was a heavy cropping year, even more so

than 1936. Certain factors in the cultural treatment of the plots resulted in the trees making very poor growth during the early part of the season and the apples did not swell as rapidly as they should have done. A very heavy set, however, resulted in a record crop. The following is the order of treatments for each variety, with the mean yield per tree for all trees of the variety under the respective treatments :—

Worcester.		Cox.		Allington.		Early Victoria.	
Treatment.	Yield. Kilos.	Treatment.	Yield. Kilos.	Treatment.	Yield. Kilos.	Treatment.	Yield. Kilos.
4	33	4	49	1	90	4	74
5	28	1	47	4	85	2	73
3	26	2	44	2	74	3	59
2	25	5	44	3	68	5	32
1	14	3	34	5	67	1	30

The first point to notice is that of these four varieties the highest mean yields per tree have been given by the Modified Leader trees in three of the varieties and in the fourth it is the second highest yield. It will be remembered that up to and including the 1938 crop the Regulated trees had given the highest total yield per tree, but it appears that with increasing maturity the benefits of a regular pruning are becoming evident.

Turning now to total yield per acre it is shown that these trees, which are now 12 years old from planting, have produced very high yields for such young trees. Calculating on the basis of a planting distance of 15 x 15 feet, which is the planting distance of these trees, the yields per acre in 1939 are as follows :—

Allington ..	Treatment 1.	201 lbs. per tree	17 tons 6 cwts. per acre.	
Early Victoria	,, 4.	166 ,, ,,	14 ,, 6 ,,	,,
Cox	,, 4.	110 ,, ,,	9 ,, 9 ,,	,,
Worcester ..	,, 4.	75 ,, ,,	6 ,, 9 ,,	,,
		Total yield ..	47 ,, 10 ,,	,,
		Average ..	12 tons	,,

The yield of 17 tons per acre in the case of Allington Pippin is exceptional. The yield of almost ten tons in the case of Cox is also a very high figure for this variety.

In an effort to show pictorially the appearance of these trees just prior to picking, photographs of typical trees of Cox were taken. These are given in Figures 1, 2 and 3. Figure 1 shows a Regulated tree carrying 163 lbs. of fruit, Figure 2 shows a Modified Leader tree carrying 141 lbs., and Figure 3 an Open Centre tree carrying 73 lbs. of fruit. The effect of the crop upon the shapes of the older trees can be seen by a comparison of Figures 1, 2 and 3.

In order to determine the quality of the crop, the total crop from all trees of any one treatment was bulked and run over the grader as a separate sample. The data show that there was practically no difference in the percentage of fruit falling into each size and colour grade as the result of pruning treatment. As might be expected there was a slightly higher percentage of extra fancy fruit in the trees subjected to summer pruning, but this was not sufficient to offset the reduced yields. In general, it appears clear that the value of these pruning treatments will be determined primarily by their effect upon total yield, as the effect upon sample is as yet almost negligible.

Practical Considerations.

The practical points raised by the data secured from this trial in 1939 are of immediate application. It is shown that the light pruning so constantly advocated by the many workers in this field is justified by results. The drastic, hard "spur" pruning so commonly practiced by a former generation is neither necessary nor is it conducive to the highest yields. A moderate to light pruning will give large trees in less time than any other method and will also ensure early cropping. In these days it is false economy to spend too much money on winter pruning in what is in effect a method of thinning the next year's crop.

One further point needs emphasis. It may be necessary under force of circumstances to allow certain cultivated plantations to fall down to grass during the present emergency. If this is accompanied by a light pruning the next crop following may be so heavy as to cause the onset of biennial bearing. The light pruning treatment here advocated is intended to be backed up by adequate cultural attention and manuring to ensure reasonable tree growth, say a terminal growth of 8—14 inches a year. Where the leader growth falls below this level, factors much more powerful than any introduced by pruning become dominant and orchard management must take full recognition of these factors. Where orchards are

FIG. 1. "Regulated" tree, var. Cox O. P. carrying 163lb. of fruit.

FIG. 2. "Modified Leader" tree, var. Cox O. P., carrying 141lb. of fruit.

FIG. 3. "Open Centre" tree, var. Cox O. P., carrying 73lb. of fruit.

being allowed to fall down to grass a serious effort should be made to encourage leader growth by the application of a nitrogenous top dressing, and where necessary by reasonably hard leader pruning. . In this connection it may be pointed out that, in order to be effective, the nitrogenous dressing must be applied before the end of March and the pruning must remove at least one-half of last year's leader growth. Continued shoot growth of say about 8—14 inches is an essential basis of continued production. When terminal shoot growth is allowed to fall below this level changes in the mode of cropping set in, and these, when combined with a light pruning treatment, give serious risk of biennial bearing, particularly in certain varieties. The motto for the present day emergency should be " keep the trees growing but keep the pruning down to the bare minimum consistent with orchard hygiene where growth is satisfactory."

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THE PROPAGATION OF BLACK CURRANTS FROM CUTTINGS.

By W. E. BERRY and T. SWARBRICK.

Introduction.

The black currant in recent years has proved itself a valuable crop and is outstanding amongst bush fruits as producing regularly a high tonnage per acre. The price per ton too has maintained a high level over the past six years. The importance of this fruit is likely to increase in the future rather than decline, particularly on account of its high content of Vitamin C. Black currant juice has been shown to contain three or four times as much of this vitamin as orange or lemon juice (1) and it is clear that black currants form a valuable alternative source of supply should imports of citrus fruits be curtailed during the war period.

Cuttings taken for propagating should be selected with great care in order to avoid the spread of the two common diseases of currants, "big bud" and "reversion." The former disease can be controlled by spraying, but "reversion," being a virus disease, can only be eliminated by thorough roguing of plantations combined with the control of insects which spread the infection. Cuttings taken from reverted bushes are a menace to the health of neighbouring plants and will rapidly become valueless so far as crop is concerned. Where, therefore, new plantings are contemplated, it is essential that healthy bushes be used as a source of propagating material.

The experiments described in this paper were carried out in order to investigate the utility of growth-promoting substances in the propagation of black currants and to provide a method for the rapid multiplication of existing stocks, *i.e.*, to produce a maximum number of new plants from a limited number of healthy bushes.

Winter Rooting.

In the winter of 1937 one of us (W.E.B.) attempted to improve the rooting of blackcurrant cuttings on a commercial scale in the field by the use of growth promoting substances. The grower con-

cerned had experienced a high percentage of failures in cuttings planted in winter on heavy land. The cuttings became loosened in the ground by frost and when replaced, in wet conditions, they rotted at the base before callusing occurred.

Several different growth substances were tried in an effort to induce callusing whilst maintaining the grower's normal procedure. On November 3rd, 1937, batches of 1,500 Baldwin black currant cuttings were treated respectively with α naphthalene acetic acid (1 in 10,000), β indolyl acetic acid (1 in 10,000), phenyl acetic acid (1 in 10,000 and 1 in 5,000) and "Hortomone A" ($\frac{1}{2}$ fl. oz. per gallon). After 20 hours treatment the cuttings were rinsed and heeled in. They were planted along with controls according to the usual farm routine a few days later.

On February 16th, 1938, when the soil had dried considerably and planting conditions were generally good, the procedure was repeated on similar cuttings which had been heeled in since November. α naphthalene acetic acid and β indolyl acetic acid were used. Half an inch was cut from the base of the cuttings before treatment to ensure that any callusing or rooting observed later had occurred after treatment.

Samples from all the treatments were examined on April 5th, 1938. None of the treated cuttings showed any improvement in rooting over the controls. The top growth of the spring-planted cuttings was slightly ahead of that of the winter-planted ones, but rooting was very slight, no doubt due to the dry weather.

The growth substances used are of proved efficiency in accelerating rooting in many species of plants under conditions of controlled temperature and humidity. It appears, however, that severe outdoor conditions are entirely unsuited to their use in the case of black currants.

Protective Coatings.

On February 21st, 1938, an experiment was made on a small scale to find the effect of coating the cuttings at the base with a film of some protective substance to prevent rotting. Vaseline, paraffin oil, paraffin wax, cuprous oxide, zinc oxide and $2\frac{1}{2}\%$ and 5% solutions of cellulose acetate in acetone and dioxan were used. The cuttings were planted in soil in pots in a cool greenhouse and the soil kept saturated with water. The cuttings were examined on March 29th. No rotting had occurred in any of the treated plants or in the controls, which suggests that frost injury

was the initial cause of rotting in the field. The tops were well grown in all cases except the wax-treated ones where water absorption had evidently been prevented. Root growth was almost entirely inhibited by cuprous oxide, vaseline, and paraffin oil, though no sign of injury to the stem or tops was apparent. The 2.5% cellulose acetate in acetone treatment gave slightly better rooting than the controls, but the difference was not important.

Autumn Rooting.

From a consideration of the foregoing difficulties, associated with winter rooting of cuttings in severe conditions, it appeared that considerable advantage would be gained if cuttings could be furnished with roots in autumn, ready for planting out in winter. It is obvious that if well rooted material is available in November or December, produced from cuttings taken in July or August, these can be planted out into their permanent quarters during winter and a year's nursery period obviated. Alternatively, rooted cuttings lined out in nursery rows would give much better one-year old material than could be produced by the usual method of rooting cuttings between December and April.

The following experiments show that cuttings can be very easily rooted in early autumn, and suggestions are made regarding the practical use to be made of this procedure.

(*a*) *Tip and Basal Cuttings.*

On June 16th, 1939, a preliminary test was made to compare the rooting of tip and basal cuttings from the same shoot without the use of hormones. Material was obtained from one-year shoots of Westwick Choice bushes which had been grown in pure sand in pots since February, 1938, and fed with a complete culture solution. The tip cuttings were 3-4″ long and cut to a node. The cuttings were still vegetative and only slightly lignified. The leaves at the apex were left attached. The basal cuttings were about six inches long and cut with a heel. All the leaves, which were partly senile, were removed. Fifty basal and fifty tip cuttings were planted in a peat and sand propagating bed in a greenhouse at a temperature of 75°F.– 80°F. They were watered regularly and partially shaded.

The resulting plants were lifted on August 2nd when it appeared that 100% rooting had occurred with both tip and basal cuttings. Typical specimens of the two kinds of cutting are shown in Figs. 1 and 2. The tip cuttings had produced a strong growth of robust roots. Practically no elongation of the shoot apex had occurred

FIG. 1.—Tip Cuttings taken on June 16th and lifted on August 2nd. Untreated.

FIG. 2.—Basal Cuttings taken on June 16th and lifted on August 2nd. Untreated.

FIG. 3.—Basal Cuttings taken on September 3rd and lifted on November 30th. Left: treated. Right: controls.

FIG. 4.—Tip Cuttings taken on September 3rd and lifted on November 30th. Left: treated. Right: controls.

but the leaves had expanded considerably. The basal cuttings had all rooted, but in marked contrast to the tips, the roots were sparse and thread-like. Two or three buds on each cutting had pushed into growth to form leafy shoots. Apparently the presence of leaves from the outset, on the tip cuttings, was responsible for the vigorous root growth observed, supplying carbohydrate or root forming hormones or both. The growth of new shoots on the basal cuttings, on the contrary, had no doubt exhausted some of the available carbohydrate, whilst no stimulating substances were initially available from the leaves. It is obvious then, that both tip and basal cuttings will root readily at this time of the year. The tip cuttings produced far better root systems than the basal cuttings, though better results might have been obtained with the latter if the leaves had not been detached.

(*b*) *Treatment with Growth Substance.*

A number of well-grown, one-year-old shoots of the variety Baldwin were collected from the plantations on September 3rd, 1939. All leaves were removed immediately. These shoots were then made into 9 inch long cuttings, using (*a*) the basal one-third, (*b*) the middle one-third, and (*c*) the terminal one-third. Each group of cuttings was then divided into two equal parts for the following treatments.

Treatment I.—After being tied into bundles of 15–20 the cuttings were placed in a galvanised container and a solution of a proprietary preparation of indolyl butyric acid (1 in 50,000) added to a depth of 4–5 inches. The cuttings were kept in the solution in the laboratory for a period of 24 hours at about 40°F. after which they were removed and planted at once, in the bundles, into a peat-sand soil rooting medium in a cool greenhouse.

Treatment II. These cuttings were treated exactly as those of treatment I, except that tap water was used instead of the growth substance. The cuttings were planted out alongside those of treatment one.

It should be noted that the cuttings were tied up in bundles of 15–20, and were treated and planted out in these bundles. The purpose of this will be pointed out later.

After planting out, the rooting medium was well soaked with tap water, and the cuttings covered with sacks to prevent undue evaporation.

Observations and Results.

It was noticed quite early that the hormone-treated plants retained their turgor more than the untreated ones, and that the basal cuttings in particular showed a marked bud swelling. Many of the buds on the hormone-treated basal cuttings grew out slightly and produced two or three leaves. (See Fig. 3.) In general all the hormone-treated plants showed more bud growth than the untreated plants.

The cuttings were all dug up for a detailed examination on November 30th, 1939, *i.e.*, three months later. Typical bundles of the basal and terminal cuttings of both control and treated plants are shown in Figs. 3 and 4. Reference to these figures shows that on the whole the basal cuttings showed a greater stimulation than the terminal ones, but the main fact is that in all cases the hormone treatment induced vigorous root growth as compared with the control plants. No doubt this vigorous root growth was responsible for the more vigorous bud growth of the treated plants. Since all cuttings had their leaves removed at planting time there are no complicating factors and the large differences in root development must be attributed to the hormone treatment.

The untreated basal cuttings rooted slightly better than the middle and terminal portions, though rooting was in all cases poor. In the hormone-treated material, the basal cuttings made by far the most vigorous response. Evidently sufficient carbohydrate was available for root growth without the presence of functional leaves. The comparison of tips with leaves, and bases without leaves, was made earlier in the season when stored carbohydrate would be less abundant. Nevertheless it seems justifiable to conclude that the better rooting of tips with leaves might have been due to the provision of root-forming hormones rather than carbohydrate. In this connection it is of interest that Miss Brandon (2) found no correlation between the starch content of rose cuttings and their rooting facility.

Practical Application.

It is clear that the treatment of cuttings taken in early September with indolyl butyric acid, stimulated root development to a remarkable extent. Cuttings taken in September and treated as outlined above were sufficiently well rooted by the beginning of December to be fit to plant in their permanent quarters in the field with every prospect of making a strong growth during the following

growing season. Two such cuttings planted together would make an excellent "stool." In this way a year would be saved and the cost of raising material reduced considerably.

It should be pointed out that in the latter experiment, beyond the use of a good rooting medium, *i.e.*, a sand-peat-soil mixture, the procedure is quite simple and easily carried out. The cuttings were purposely left in relatively large bundles so that the cuttings in the middle of a bundle would not be in direct contact with the rooting medium. This was intended to determine whether the cuttings could be packed like this in the cutting beds and still give a good take. In general, it may now be stated that where large quantities of blackcurrants must be raised in minimum time from a limited amount of stock material, an autumn rooting treatment such as that described, offers a dependable method.

Greenhouse conditions are preferable but by no means essential in warm weather. Solutions of pure growth substance may be used, but it is probably simpler for the grower to use one of the proprietary products obtainable from horticultural sundriesmen. The concentrated solution should be diluted according to the maker's directions, but in no case should the diluted solution be kept more than 48 hours.

Summary.

1. Experiments are described in which the application of growth hormones to blackcurrant cuttings has been investigated.

2. In winter conditions in the field, no improvement in rooting was obtained. At this time of the year controlled conditions of temperature and humidity are essential. Planting in February showed no improvement over November planting.

3. Protective coatings applied to the cuttings in most cases reduced rooting. No information regarding prevention of rotting was obtained.

4. Both tip and basal cuttings taken in June were well rooted in a propagating frame, by August, without hormone treatment. Terminal cuttings with leaves were vastly superior to basal cuttings without leaves.

5. Terminal, middle and basal cuttings, taken in early September and with leaves removed, all gave very much improved rooting when treated with indolyl butyric acid.

6. In the treated material, the basal cuttings made most root growth.

7. It is suggested that the importance of attached leaves lies in the production of root-forming hormones rather than carbohydrate.

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A METHOD OF TREE STAKING—ITS USE FOR BUSH TREES.

By H. G. H. KEARNS.

Efficient tree staking and tying are essential for the satisfactory establishment of a new planting of bush fruit trees. In many plantations the staking must be continued for about five years, or until the trees have developed a sufficiently extensive root system to form a satisfactory anchor to withstand all normal strains caused by wind. In some parts of the country, more especially in the West, March and September gales are of considerable severity and they cause extensive damage to young trees which are insecurely staked and tied. Usually the most serious damage occurs in September when the trees are relatively heavy with foliage and fruit.

Many methods of staking bush trees are used, the majority utilising a wooden stake and some form of rope or combination of rope, wire and rubber tie. Most of them fail under severe weather conditions, either because of the stake breaking at or above ground level or by the tie snapping or working loose. These failures frequently result in serious damage to the bark of the trees. Apart from damage to the trees, nearly all types of stake and tie demand regular attention to replace breakages and to make adjustments to allow for the growth of the tree. This attention is essential and increases the total cost of staking.

Experience has shown that square wooden stakes of economic dimensions of $1\frac{5}{8}$"–2" often fail during their required life of approximately five years, either by rotting and or fracturing. The rotting occurs at ground level and is followed by fracturing. The latter also occurs at dried-out knots. Rotting may be overcome by creosoting the timber either by the pressure or the hot-and-cold steeping methods, but these processes add a third to the cost of the stakes and do not overcome fractures at knots nor difficulties in tying. Cedar wood resists rot but the wood is too brittle for satisfactory commercial use. Oak stakes of reasonable economic proportions are unsatisfactory, unless carefully selected and free from large knots and sapwood. If they consist of much sapwood they must be dipped in creosote before use.

In view of the disadvantages of the usual methods a modified form of the Healey self-expanding tree band has been devised for use in conjunction with disused boiler tubes as a means of providing a relatively cheap, trouble-free and long-lived method of staking.

The standard Healey band is made for fitting by means of felt nails to relatively stout tree stakes. Experience has shown that the tie is satisfactory and despite its relatively high initial cost its use is economic over a period of five years. Various sizes are made to suit trees of differing sizes of stem. A simple modified band has been designed so that one size of band is suitable and adjustable for all sizes of young trees up to $2\frac{1}{2}''$ diameter of stem at the level of tying, and a method devised of fitting the band to a boiler tube used as a tree stake.

The Design of the Band.

The design is shown in Plate 1 and consists of three main portions, an outer split ring of steel hoop, an inner split adjustable ring and a strip of moulded flanged rubber. The outer ring (*a*) supports the inner ring (*b*) by means of a rivet (*r*) and forms the attachment to the boiler tube. The inner ring fits round the tree and forms a support for a strip of rubber which rests on the bark and protects it from rubbing. The diameter of the inner ring is adjusted to suit the size of the tree by bending the tail pieces (*t*).*

The dimensions and particulars of the band are as follows :—

Outer strip (*a*)—Total length	$21''$
Inner strip (*b*) ,, ,, ...	$10\frac{1}{2}''$
Rubber strip (*rs*) ,, ,, ...	$8''$
Strip galvanized mild steel hoop ..	20 G. $\times \frac{7}{8}''$
Size of holes	$\frac{1}{6}\frac{3}{4}''$
Rivet (*r*) black tinsmiths	No. 10

Positions of holes in the strip—

(*a*) Outer, measured from one end, $2\frac{1}{2}''$, $11\frac{1}{2}''$, $18\frac{1}{2}''$

(*b*) Inner ,, ,, ,, $5\frac{1}{4}''$

Size of cotterpin (*c*) for attachment to boiler tube, $2\frac{1}{2}'' \times \frac{3}{16}''$

* Plate (1) shows two holes in the band at (*x*). These holes were intended for a wire tie or $\frac{1}{2} \times \frac{3}{16}$ in. galvanised screw bolt or nut as a means of keeping the cut ends of the outer ring of the band together. In practice this procedure has been found unnecessary except in exceptionally exposed situations.

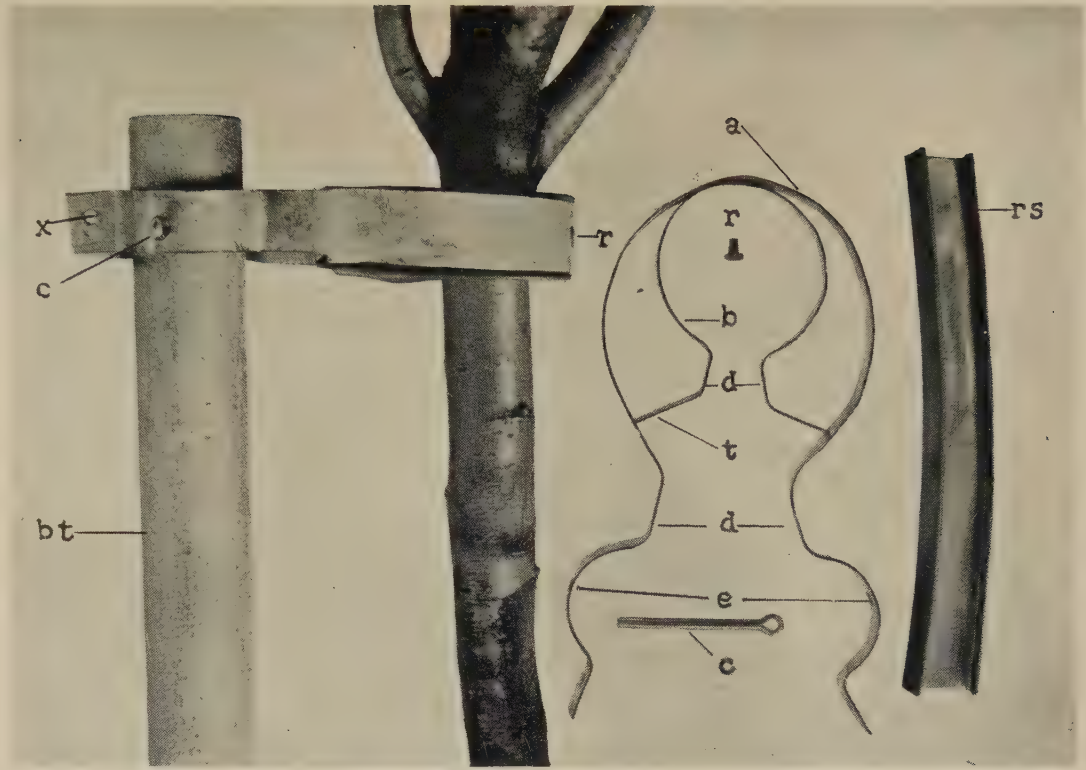

PLATE 1. Showing Tree Band in position and Parts of Band :—(*a*) outer ring ; (*b*) inner ring ; (*bt*) boiler tube ; (*c*) cotter pin ; (*d*) flat area ; (*e*) holes for cotter pin ; (*r*) rivet ; (*rs*) rubber strip ; (*t*) tail pieces ; (*x*) holes (see text).

Cost of Materials.†

Steel hoop 1 cwt. = 1,000′	35/-
Cotter pins per gross	1/4
Rivets per 1,000	9d.
Rubber strip per foot	1½d.
Cost per band	2½d.

The simple method of making them is as follows :—

The hoop is purchased in coils and cut to lengths by hand or foot operated shears. The holes are drilled through templates by means of a power-driven pillar drill or more quickly in one motion by a set of adjustable drill spindles. The strips are then bent to shape around swages. A simple swage for the inner ring may be made from a section of steel tube 2¼″ external diameter set up securely and with a locating peg over which the middle hole is placed so that the tails (*t*) of the ring are of equal length. The strip is bent round the steel tube by a quick acting vice, then the two halves of the strip at (*d*) are held in a clamp with ⅞″ square jaws and the strip bent out into tail pieces (*t*).

The swage for the outer ring can be made from sections of ⅝″ and 3½″ steel tube. The middle hole (11½″) in the strip is fitted over a locating peg in the wall of the 3½″ tube ; the strip is then bent round the tube by the quick acting vice so that the cut ends of the strip are equidistant from the centre hole. The two halves of the strip (*d*) immediately next to the bent area are held by the clamp with ⅞″ square jaws and finally the remaining portions of the strip are bent in the vice around the 1⅝″ diameter tube. If the above operations have been carried out correctly the two holes(*e*) should coincide. Finally, the inner ring is riveted to the outer ring by means of a tinsmith's flat headed rivet (*r*).

The Boiler Tube.

Disused boiler tubes of 1⅝″ external and 1⅜″ internal diameters from railway locomotives have been found satisfactory. The most convenient lengths for bush trees are 6′ or 7′. These lengths permit of 2′ or more to be driven into the ground.

The boiler tubes prior to use are drilled right through their full diameter at 2″ from one end with a $\frac{7}{32}$″ drill to permit of the fixing of the band by a $\frac{3}{16}$″ cotter pin. The hole should be made oversize

† Retail cost prior to September, 1939.

because a certain amount of longitudinal telescoping may occur during the driving of the tube into the soil and thereby causing a closing of the hole and consequent difficulty in fitting the cotter pin.

It is important to prevent water remaining in the tube during frosty weather in order to prevent possible splitting of the wall of the tube. The entry of the water may be prevented by driving a tapered creosoted shive into the open end of the tube, but this is sometimes rendered difficult on account of damage caused to the end of the tube by the driving. A simple alternative is to drill one or two drainage holes in the wall of the tube at places that will be at or just above ground level when the tube is driven in.

The tubes may be driven into the ground by means of a sledge-hammer hitting a nickel steel dolly fitted over the end of the pipe to prevent undue damage. The dolly must be a loose fit over the tube otherwise difficulty will be experienced in removing it. A better and much quicker method is to use a " Drivall " stake driver. The tube is driven down until a water drainage hole is at ground level when the hole is cleared of earth with a reamer. Care should be taken to drive the stake in on the windward side of the prevailing winds striking the tree, and at a distance from the stem so that the band will be under slight tension.

The procedure of fitting the band is as follows : The cotter pin-hole in the pipe is tried with the pin and if tight is reamered out. The band is slipped over the tree stem and the boiler tube. The cotter pin is inserted through the band and tube, and opened out. Finally the inner ring of the band is adjusted to fit the stem.

The boiler tubes used were of suitable dimensions and price. The cost in July 1938 of tubes of $1\frac{5}{8}''$ diameter was $1\frac{1}{2}$d. per foot cut to size and delivered.

The tubes are best dipped, preferably after drilling, into a mixture of equal volumes of old engine sump oil and kerosene, as this ensures that undue rusting does not occur during storage. Rusting under field conditions is not rapid and it is doubtful if it would be economical or effective to dip them in a rust preventive paint.

The rubber strips of the bands tend to crack at the extreme position of the bend, due to the influence of sunlight, and cannot be entirely avoided. The cracking does not cause displacement of the strip from the tree.

SPRAYING FARM ORCHARDS IN WAR TIME.

By H. G. H. KEARNS and H. MARTIN.

Does it pay to spray farm orchards? This question has often aroused much discussion in peace time and there is no simple answer, for each farmer's problem is different.

The farm orchard may consist entirely of cider varieties, as commonly occurs in Herefordshire, or it may comprise a mixture of cider and culinary sorts as in Somerset or in Devon. The orchard may be newly planted, in prime cropping condition, or derelict. The damage done in orchards by pests and diseases depends partly on the fruit varieties present and the locality. A spray machine may already be available but, more generally, there is not and special capital outlay is necessary. These are some of the points which have to be considered by the farmer before he decides whether or not to spray.

But there is another important point, common to all cases—the relatively low price the farmer obtains for his fruit. Cider apple requirements in a short season are normally met by importation or by an increased use of culinary varieties, whilst "pot" fruit from the farm orchard, if sold for culinary purposes, has to compete with better packed fruit of high quality from fruit farms. So the farmer always gets a low return per ton for his fruit, which means that the increase of yield resulting from good orchard management and from the control of insect pests and fungus diseases must be high to repay the trouble and expense.

But in war time other conditions prevail. The quantity factor becomes of relatively greater importance and the importation of cider fruit, if not entirely prohibited by economic expediency, becomes expensive. Except in glut years, the farmer has greater reason to expect a good return for his crop and he will wish to reconsider the question of spraying. There are already a number of articles (1, 2, 4, 6 and 7) dealing with various aspects of pest and disease control which may be consulted but, under present conditions, a survey of the problem and of the practical difficulties may help farmers to reach decisions regarding the special war-time problems of their particular orchards.

Since the majority of farm orchards in the West consist mainly of apples, emphasis is given in this article to the special problems of this fruit.

Common Pests and Diseases in Farm Orchards.

The more common pests of apple trees in farm orchards are various species of aphides, Apple Sucker, caterpillars of the Winter and Tortrix Moths, Apple Blossom Weevil and Fruit Tree Red Spider and occasionally Capsid Bugs. Apple Scab and Apple Canker are the prevalent fungus diseases. Lichens are found in nearly every unsprayed orchard.

A severe infestation of lichen prevents the healthy development of new wood and of blossom buds, and the consequent absence of luxuriant foliage renders the tree less subject to insect infestation. As soon as lichen is removed from infested trees by winter washing the liability to insect attacks increases. Thus, for example, within three seasons of successive winter washing with tar oils, Red Spider infestations may become so serious that they interfere materially with the health of the tree. It is therefore most important to select winter washes or to adopt a spray programme that will control as many as possible of the important pests as well as lichen. The only pest of those mentioned above that cannot be controlled economically by spray treatment is the Apple Blossom Weevil.

Apple Scab is a major fungus disease, especially of dessert varieties, and some cider varieties are often badly attacked, but whether it pays to control the disease in such cases, when prices are low, has yet to be determined.

Some varieties of apple, more especially when the trees are young and making vigorous growth, are subject to serious infection by Apple Canker, but little can be done to control the disease beyond avoiding soil treatments encouraging rapid wood growth.

Recommended Spray Programmes.

The programme selected will depend on the nature of the orchard :

(*a*) *Newly Planted Orchards.* The newly planted orchard (4) will repay the expense of keeping free from pests. The most satisfactory programme consists of the early application of a tar-petroleum oil wash or of dinitro-ortho-cresol-petroleum oil wash from mid-December until mid-March, *i.e.* up to just before bud burst. Late applications within this period give the best results. This winter washing should be continued until the trees are in profitable bearing when they should be treated as in (*b*).

(*b*) *Established Cider Orchards.* An orchard that has a reasonably full complement of yielding trees and which has not received any spray treatment should be winter-washed as recommended above for (*a*) for two or more successive seasons. Very liberal applications of the washes are required. Once the trees are reasonably free from pests, winter washing can be omitted on most cider varieties and frequently on culinary sorts such as Bramley's Seedling for two or more seasons. The interval between the winter applications will depend very largely on local conditions. Spraying with a combined lime sulphur-lead arsenate wash in spring should be adopted if there is sufficient evidence to show that a reduction in the infection of Scab or infestation with Tortrix Moth might justify the expense of the application. This combined wash should be applied at a time to coincide with the late pink bud stage of the predominating varieties in the orchard. A Bordeaux mixture-lead arsenate combined wash may be substituted for the lime sulphur combination in some instances. If a simple tar oil wash is used in winter instead of washes including petroleum oil, it is imperative that a lime sulphur-lead arsenate wash be applied in the spring, preferably at the end of May to control Red Spider.

(*c*) *Old Farm Orchards.* The farm orchard often consists of trees of very varied ages and conditions, and often such an orchard will not repay winter washing. The partial renovation of an old orchard by planting young trees near old trees also presents a special problem in pest control. The young trees require an annual winter washing which may be carried out with relatively cheap equipment, but the older trees cannot be sprayed without the use of an expensive spray outfit. Yet if the old trees are left unsprayed, there is risk of their being a source of serious insect infestation of the young trees. If it appears that the orchards will repay for spraying the programme recommended for (*b*) should be adopted. It should be noted that all the trees should be sprayed.

(*d*) *Mixed Farm Orchards.* Some farm orchards consist of "mixed" fruit and may have a large proportion of apples other than cider varieties. The spray programme in these may not be confined to apples. Full details can be obtained from other publications (3). Perry pears, cherries, damsons and plums may all be sprayed with

the winter washes as recommended for apples as their main spray requirement, but it is advisable to complete the spraying by the middle of January. Some varieties of plums, such as Victoria, are occasionally damaged by high concentrations of oil when they are sprayed later than the end of December.

Freshly planted and established orchards undoubtedly repay the expense of a well balanced spray programme. In the case of the old orchard it is often difficult to estimate by a single inspection whether spraying will be profitable on account of a number of local factors, such as the liability of the trees to pests, the cost of and facilities for spraying, etc., and experience and circumstances must be deciding factors.

Spray Materials.

Details of the washes mentioned in the programme above are as follows :—

(1) *Tar-Petroleum Oil Wash.**

The wash must be applied at a concentration of not less than 3.0 per cent. Grade A tar oil (5) and 5.0 per cent. Grade E petroleum oil (5). Only concentrates of declared composition should be purchased. In order to obtain the necessary concentrations of oils most of the proprietary concentrates require dilution to 10–11 per cent.

(2) *Dinitro-ortho-cresol Oil Wash.*

The wash should be applied at a concentration of not less than 0.1 per cent. dinitro-ortho-cresol and 5.0 per cent. Grade E petroleum oil (5). This is approximately equivalent to $7\frac{1}{2}$ per cent. solutions of some proprietary concentrates.

(3) *Lime Sulphur and Lead Arsenate Wash.*

3 gall. lime sulphur (1 gallon only if applied after petal fall).
2 lb. lead arsenate powder (or equivalent in paste).
$\frac{1}{2}$ lb. Wetter, *e.g.* Agral II or Lethalate Wetting Preparation
or Sulphonated Lorol
or one quart Shell Sulphonate B Wetter.
Dilute to 100 gallons water.

* This type of wash is preferred to the ordinary tar oil wash, but if the latter type is used the wash should conform to the specifications agreed to by the Ministry of Agriculture and the Association of British Insecticide Manufacturers.

(4) *Bordeaux Mixture and Lead Arsenate Wash.*

4 lb. copper sulphate.
6 lb. hydrated lime.
2 lb. lead arsenate powder (or equivalent in paste).
¼ lb. Wetter, *e.g.* Agral II or Lethalate Wetting Preparation or Sulphonated Lorol
or one pint Shell Sulphonate B Wetter.
Dilute to 100 gallons water.

Add the 6 lb. hydrated lime to 90 gallons water, and dissolve the 4 lb. of copper sulphate in 4 gallons water. Add the copper solution gradually to the lime water, stirring to ensure thorough mixing. Finally add the lead arsenate and wetter and make up to 100 gallons.

Methods of Spraying.

The efficient spraying of farm orchards presents a difficult problem. The trees are often large and therefore require a spray pump of large output and high pressure, but on the other hand the acreage may be small and the trees may be sprayed only once a year or even less frequently. It is evident that it would not pay the owner of a small orchard to purchase an expensive spray outfit, but there is no doubt that a well-planted orchard of 15 acres or more justifies the expenditure on an efficient sprayer over a period of years. The spraying of an orchard of less than 15 acres is perhaps best met by some form of contract spraying.

An orchard can be sprayed for about 5 years after planting by means of a manually-operated headland pump. This type of outfit consists of a pump, mounted on a platform fitted with wheels, which sucks the wash from a container and pumps it at about 80 lbs. pressure along a rubber hose of up to a length of about 150 ft. to the spray man. Numerous modifications of this type of outfit are available.

As soon as the trees begin to bear and become large a more powerful pump becomes essential. Winter washes in most cases can be applied over a relatively long period, namely, from mid-December until the end of March, and the time occupied in the spraying is therefore not of great moment. A pump capable of delivering not less than 7 gallons per minute at 350 lbs. pressure per square inch is sufficient to employ two spray men. Two types of outfits are suitable for most orchards and consist either of a complete unit of a tank of about 150 gallons or more capacity, a pump, and an engine, the whole outfit being horse or tractor drawn, or of a

pump and engine mounted on a trailer chassis and fed from conveniently placed containers. Many simple arrangements for transporting the pump and wash can be devised ; on reasonably level ground, for example, a convenient method is to use an old lorry or car chassis. On hill slopes, it may be more convenient to pump the wash from headlands through an overland steel main fitted with cocks at convenient intervals along its length. Long lengths of rubber hose should be avoided because of the loss of pressure on lengths of more than 300 feet, due to frictional resistance of the rubber and elasticity of the walls.

The wash may be applied by means of spray guns or lances. For tall trees lances are generally better suited, especially the type fitted with adjustable double nozzles and which can be quickly altered from 4 to 8 feet in length by means of extension pieces. An intelligent use of the adjustment devices and discs enables every special spraying need to be met. Generally flat discs of 6/64″ aperture are satisfactory for smaller trees and taper discs of the same aperture for tall trees. A spray gun is more convenient in use on account of its short length and the fact that it permits an immediate adjustment of the pattern of the spray jet, but it requires intelligent usage to avoid undue waste of wash.

The most essential points in spraying standard trees are that the outermost and uppermost fine branches must be thoroughly wetted. The lichen-covered tree must be drenched and the best results are obtained if the spraying is done when the lichen is relatively dry, as in a wet condition its absorptive capacity for the wash is small. The tree must be sprayed when the bark is dry and under weather conditions that ensure rapid drying of the wash. Under no circumstance should spraying be done if frost is likely to occur before the wash has dried on the tree.

Each spray man should adhere to a definite method of spraying a tree as it prevents fatigue and ensures uniform results. The top of the tree should be sprayed first and liberally, and there is little object in drenching the large limbs of the trees unless they are lichen-covered. Each spray man should be supplied with adequate clothing for his task.

Notes on the Cost of Spraying.

The cost of winter spraying (6 & 7) an orchard varies considerably, but the following notes will help in calculating the cost. A 4 h.p. spray outfit of 7 gallons output per minute is taken as the type used. Amount of wash required per acre :

Young trees	70 galls per acre.
12 year old trees	250 „ „ „
Well-established trees	600 „ „ „
Amount of wash applied per day—up to 1,000 gallons.	
Acreage of well-established trees sprayed per day	say, up to 2 acres.
Cost of wash :	
(*a*) Tar oil-petroleum wash (ready for spraying)	23/- per 100 galls.
(*b*) Dinitro-ortho-cresol-petroleum wash (ready for spraying) ..	19/- „ „ „
Cost of spray outfit, say	£130.
Depreciation of spray outfit	£26 per annum.
Interest on capital outlay	£7 „
Repairs and replacements of spray outfit	£5 „
Cost of running outfit per acre, excluding labour, say	1/6d.

Prices, September 1939.

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NOTES ON THE USE OF CERTAIN SULPHUR PREPARATIONS IN APPLE SPRAYING.

By R. W. MARSH.

One after-effect of the spring frosts of 1938 was a heightened interest in the problem of lime sulphur spray damage. In that year, there were widespread reports that the injuries due to low temperature were being aggravated by the effects of lime sulphur injury. In consequence, special attention was directed to the possibilities of using some other sulphur-containing spray which would combine safely on foliage with effectiveness in controlling scab.

Development of Lime Sulphur Substitutes.

Within the past twenty years the development of sulphur sprays has been rapid, and new preparations are constantly being placed on the market, both in this country and overseas. In England, ammonium polysulphide was introduced, following the investigations of Eyre, Salmon and Wormald (1), and was largely used in greenhouses and on gooseberries for many years. The majority of the lime sulphur substitutes now produced in this country are, however, prepared by the grinding of sulphur, usually in the presence of a protective colloid, to form a paste containing elemental sulphur in a finely-divided state. These pastes are marketed as " colloidal " sulphurs. By similar grinding processes, dry products are made consisting of elemental sulphur together with a wetting agent. These are usually termed wettable sulphurs and are mixed with water when required to make a suspension for spraying purposes.

In America, mixtures of sulphur, hydrated lime and casein have been used for many years under the name of " dry mix." A more recent development arises as a result of new processes for the purification of city gas supplies from sulphuretted hydrogen. These processes consist essentially of the absorption of the sulphuretted hydrogen by a reagent which on subsequent treatment with air releases elemental sulphur. In the older process commonly used in Europe the gas was passed through iron hydroxide which interacts with the sulphuretted hydrogen to give iron sulphide. Iron

sulphide, in the presence of air, re-forms iron hydroxide plus elemental sulphur. In this process, however, the sulphur is not mechanically separated from the hydroxide and has to be specially recovered.

The systems of gas purification now used in U.S.A. (10) are characterised by the direct production of finely-divided elemental sulphur in a form suited for spraying purposes, without further processing. In the *Ferrox* process a solution of soda ash containing ferric hydroxide in suspension absorbs the sulphuretted hydrogen and then, on the addition of a limited amount of air, releases the sulphur which is floated to the surface of the liquid. The so-called "flotation sulphur" thus obtained contains traces of ferric hydroxide. A purer product is given from the *Nickel* process, which utilises a nickel catalyst suspended in sodium carbonate solution as the absorbent.

The method now most extensively used in U.S.A. is the *Thylox* process, employing a solution of sodium thioarsenate. This absorbs the sulphuretted hydrogen, and on subsequent oxidation liberates elemental sulphur in a high state of purity. The sulphur is floated to the top by the incoming air and then filtered off. The filter cake gives a very finely-divided sulphur with 95 per cent. of the particles less than 3 microns diameter.

This sulphur may be used as it comes from the filter in the form of a paste containing 50 per cent. water. This paste can be diluted, without further processing, to form spray suspensions. Alternatively, the paste may be dried to give a dusting sulphur, or it may be dried after adding wetting agents to give a wettable sulphur in powder form, which can be diluted with water to form a spray. These three types—the paste, the dust and the wettable powder—are all common in the American market.

Physical Characteristics of Lime Sulphur Substitutes.

The colloidal sulphurs, wettable sulphurs and sulphur pastes show certain physical characters in common. They are all free from the odour and corrosive properties which are two of the main disadvantages of lime sulphur. On the other hand they are suspensions and as such are open to objections from which lime sulphur, being a solution, is free. All suspensions tend to settle out at a more or less rapid rate. This applies to all the sulphur products on dilution, and to the paste and colloidal products in the concentrated form. The settling out of the concentrates may lead to the deposition of intractable clay-like masses which are very

difficult to re-disperse. There is also, particularly in the use of the wettable powders, a frequent difficulty in making a diluted suspension which will remain uniform. This problem is more frequently encountered in this country than in America where it is usual to equip the tanks of spraying outfits with efficient agitators.

For large-scale commercial spraying, the relative expense of lime sulphur and of other sulphur sprays is a point which must be considered. A useful basis of comparison is the fact that the spray made up from one gallon of lime sulphur concentrate deposits on drying not less than 2½ lb. of finely-divided sulphur. Therefore 5 lb. of sulphur paste, with a content of 50 per cent. sulphur by weight would have to be used to give the equivalent weight of sulphur, disregarding any question of the relative effectiveness of the form in which the sulphur was deposited. At present prices, a given weight of sulphur can be bought more cheaply in the form of lime sulphur than in any other sulphur spray preparation.

In the apple spraying programme the compatibility of fungicidal sprays with lead arsenate is of great importance. The combination of lime sulphur with lead arsenate has been much studied, and the conclusion may be drawn that although the mixed wash is a great convenience to the grower its use on apples is attended by a risk varying with the sensitivity of the tree to spray damage. Ammonium polysulphide cannot be used with lead arsenate as this mixture gives rise to soluble arsenic compounds highly damaging to apple foliage. On the other hand the addition of the sulphur pastes and powders to arsenates has not been shown to increase the risk of foliage injury.

Use of Sulphur Pastes and Wettable Sulphurs Overseas.

In Canada and the United States the major objective of the commercial apple spraying programme is the control of Codling Moth. For this reason, frequent post-blossom arsenical applications are recommended, the number varying from four in Nova Scotia to ten in the Western and Southern apple-growing regions. Spraying against apple scab has therefore to be superimposed on this foundation of continual arsenic applications. The addition of lime sulphur in these numerous arsenical sprays is often damaging, more particularly in the hot summers usual in U.S.A. Lime sulphur substitutes have therefore been widely recommended for continued application in combination with lead arsenate and lime. The strengths commonly advised are 3 lb. arsenate, 3 lb. lime and 6–15 lb. of sulphur paste, or 5—10 lb. wettable sulphur, per 100 U.S. gall. of water (=80 Imperial gallons).

It should be noted that these sulphurs are used for post-blossom applications repeated at short intervals (10—14 days) and that they are invariably used in a combined spray. They are not relied upon for pre-blossom applications.

In apple spraying in New Zealand, it is common practice to use 0.2 per cent. colloidal sulphur, reinforced with weak lime sulphur (0.5—0.7 per cent.). It is claimed that the colloidal sulphur is of special value in the control of mildew. As in America, Codling Moth is a serious pest in New Zealand, and lead arsenate at $1\frac{1}{2}$ lb. per 100 gall. with lime at 3 lb. per 100 gallon is included in all post-blossom spray applications.

Use of Lime Sulphur Substitutes in England.

Under English conditions, Codling Moth is normally of minor importance and the use of post-blossom washes for the control of biting insects is ancillary to their main function which is the continued prevention of scab. Consequently the use of arsenates in the summer months is not a frequent practice and has tended generally to decline. The standard fungicide is lime sulphur varying in strength from 1.5 down to 0.75 per cent., and the number of post-blossom applications given is rarely more than two.

Scab Control.

Published results of apple scab control experiments carried out in England with sulphur pastes and powders relate almost entirely to colloidal sulphurs. Moore (7), reporting on a five years' trial with a proprietary colloidal sulphur, states that at 0.4 per cent. it gave less satisfactory results against apple scab than lime sulphur at 1 per cent. Moore and Montgomery (9) record that two proprietary colloidal sulphurs (40 per cent. S) used at 0.5 per cent. pre- and post-blossom gave results slightly inferior to those for lime sulphur at 1 per cent. Summing up the position in 1939, Moore concludes that colloidal sulphurs at 4—5 lb. per 100 gall. are a useful alternative to lime sulphur for post-petal-fall applications, their drawback as compared with lime sulphur being cost.

A wettable (so-called "micronized") sulphur, prepared by grinding, was tested by Moore and Montgomery in 1936 (9), but at 0.5 per cent. it did not give satisfactory control of scab.

Grubb (3) tested ammonium polysulphide for the control of apple scab. Comparing 1 per cent. A.P.S. with 1.7 per cent. lime

sulphur, for post-blossom spraying, he obtained the following figures :—

Variety.	Clean Fruit per cent.	
	L. S. sprayed.	A. P. S. sprayed.
Cox	91.7	86.4
Allington	89.8	78

He further records that scab infection of shoots was more prevalent on the A.P.S. sprayed block. In another paper on scab control published in 1923 (4) Grubb notes that 1 per cent. A.P.S. was inferior as a fungicide to Bordeaux mixture 6—20—100.

An experiment was carried out at Long Ashton in 1939 on a plantation of 7-year-old Cox and Worcester trees. Certain blocks were sprayed with lime sulphur at 2 per cent. on May 2nd and 1 per cent. on June 6th. Alternating with these were other blocks sprayed with ammonium polysulphide at 2 per cent. on May 2nd and 1 per cent. on June 6th. Transversing all treatments was a block of unsprayed trees. No wetters or insecticides were added to any spray and all applications were made in heavy amount, using a 9 h.p. sprayer and a pressure of 350 lb. per square inch. Counts were carried out on the trees on August 11th. Every apple in the plot was examined and all fruits showing any scab whatsoever were recorded as scabbed. The results were as follows :—

Treatment.	Results on Worcester.				Results on Cox.			
	No. of trees.	Total fruits.	Mean per tree.	Per cent. Scab.	No. of trees.	Total fruits.	Mean per tree.	Per cent. Scab.
A. P. S. ..	72	839	11.7	5.1	71	1798	25.3	2.2
L. S. ..	60	873	14.6	9.9	34	701	20.6	4.6
No spray ..	45	411	9.1	51.1	63	1141	18.1	34.7

The shape of the plot made it difficult to compare statistically the results from the two sprays, but by computing the figures from four suitable sample blocks, each traversing all the treatments, it was found that the advantage in scab control shown by A.P.S. over L.S. of equal strength was not significant. No evidence of spray damage appeared with either treatment.

In commercial apple growing, ammonium polysulphide has never been greatly used, its disadvantages being cost and incompatibility with lead arsenate.

Mildew Control.

Sprays applied for the control of Apple Scab often reduce infection by Apple Mildew. Moore (6, 7) records that all sulphur-containing sprays reduce the incidence of mildew but that lime sulphur was superior to colloidal sulphur, ammonium polysulphide, liver of sulphur and a proprietary sulphur spray. In a trial maintained at Long Ashton since 1937 on Cox's Orange Pippin, each of six groups of 40 young trees was sprayed according to one of the following programmes. The dates of application given are those for 1938.

Plot.	Spray.	Strength per 100 gall. applied April 7.	Strength per 100 gall. applied June 9.
A	Lime sulphur	3 gall.	1 gall.
B	Lime sulphur	3 gall.	1 gall.
	Hydrated lime	8 lb.	8 lb.
	Casein	2 lb.	2 lb.
	Cottonseed oil	1 gall.	1 gall.
C	Wettable sulphur (U.K.) ..	6 lb.	3 lb.
	Hydrated lime	8 lb.	8 lb.
	Casein	2 lb.	2 lb.
D	Wettable sulphur (U.K.) ..	6 lb.	3 lb.
	Gelatine	1 lb.	1 lb.
E	Flotation sulphur cream (U.S.) ..	20 lb.	10 lb.
F	No spray		

Estimates of mildew infection on the trees in these plots were made in the spring of 1938 and compared with those made one year later, with the following results :—

Plot.	Total of mildewed trusses. 1938	1939	Percentage increase or decrease.
F	43	86	100% increase
C	87	106	22% ,,
A	72	84	17% ,,
D	126	137	9% ,,
E	71	75	6% ,,
B	73	63	14% decrease

It will be noted that all the treatments have considerably checked the increase of mildew as compared with the control but that the only application which has actually reduced infection is the lime sulphur-casein-oil spray, a treatment which is too damaging for general recommendation on Cox's Orange Pippin.

Phytocidal Effect.

Concerning phytocidal effect, it is commonly agreed, both in this country and overseas, that lime sulphur is the most damaging of the sulphur sprays in common use. The grower overseas, however, is not faced with the problem of the English sulphur-sensitive varieties such as Stirling Castle and Lane's Prince Albert, on which sulphur sprays of all descriptions are potentially dangerous.

Frampton (2) carried out spray damage tests on trees of Stirling Castle, comparing lime sulphur, ammonium polysulphide and colloidal sulphur. Gelatine and soap were included in certain of the sprays. Three applications were made, pre-blossom on April 29, post-blossom on May 31st and July 13th. The count of fallen leaves made on July 20th showed the following results :—

Treatment.	Mean number of fallen leaves per tree.
L. S. 1% + gelatine.. ..	164.7
L. S. 0.7% + gelatine ..	100.6
A. P. S. 0.5% + gelatine ..	105.5
A. P. S. 0.5% + soap ..	34.0
Colloidal sulphur 0.5% ..	27.0
Control	15.9

Grubb (3) records the following mean yields per tree following post-blossom spraying given on June 7th and June 27th, 1919.

Treatment.	lb. of fruit per tree.	
	Cox.	Allington.
Lime sulphur 1.7% ..	5.5	6.3
A. P. S. 1%	12.3	11.7
No spray	3.3	7.0

Maynard and Marsh (5) record that as a result of spraying post-blossom with colloidal sulphur at 1 per cent., trees of Stirling Castle were one-half to two-thirds defoliated, while on a block of Lane's Prince Albert (previously weakened by winter injury) the same spray brought about a shedding of 90 per cent. of the fruits set.

An experiment of which the results have not hitherto been published was carried out at Long Ashton on June 15, 1937, when trees of ten commercial apple varieties were used for phytocidal tests of the following spray applications :—(*a*) lime sulphur 1 per cent., (*b*) an American flotation sulphur paste at 0.3 per cent., (*c*) an English ground sulphur wettable powder at 0.3 per cent. On the varieties Allington, Bath, Blenheim, Grenadier, Worcester and Bramley, there was no apparent damage from any spray. For the remaining varieties the mean yields of fruit per tree are assembled in the following table :—

Mean Yields of Apples per Tree following Spray Treatments.

Treatment.	Variety.			
	Lane.	Rival.	Newton.	Cox.
No spray..	209	389	551	695
Lime sulphur	11	40	171	173
Wettable sulphur ..	54	139	222	111
Flotation sulphur ..	71	105	230	297

This table brings out the serious crop reduction due to post-blossom lime sulphur spraying on these sensitive varieties and shows that while this damage is generally lessened by the use of the other sulphur sprays, it is by no means obviated.

The examples of spray damage given above show a lack of uniformity which is not surprising since the amount of spray damage depends on many environmental factors of which the influence has not been fully determined. But, in general, it appears clear that the circumstances favouring damage by lime sulphur are also those which favour damage by the sulphur pastes and powders, although the degree of this damage is usually less than that due to lime sulphur.

Discussion.

There is an obvious lack of information concerning the efficiency of the newer sulphur preparations in controlling Apple Scab in this country. For the colloidal sulphurs, it is generally agreed that they are somewhat inferior in fungicidal power to the lime sulphur concentrations yielding equivalent sulphur deposits. The evidence from overseas is that the wettable and flotation sulphurs similarly rank below lime sulphur in ability to control scab. Under American conditions, however, a compensation for the loss of effectiveness per application is provided by the number and frequency of applications. Further, the addition of arsenate and lime to each sulphur spraying enhances both fungicidal power and tenacity.

In the application of wettable and flotation sulphurs in England, these points concerning American conditions should be borne in mind. These sulphur products are useful in circumstances where frequent summer applications are practicable, and at present should be considered as adjuncts to the main scab control programme. There is no evidence to justify their use to displace lime sulphur from the applications up to and including petal fall. On the subject of spray damage there is evidence that colloidal sulphurs, wettable sulphurs and flotation sulphurs are all less injurious than lime sulphur, but all these sprays are able to cause damage to the sulphur-sensitive varieties. In conditions conducive to spray injury any of these sulphur-containing products may cause serious leaf shedding and fruit drop. A correction of the conditions such as nutritional deficiencies pre-disposing to damage is likely to be of more value to the grower than a weakening of his spray treatments to a level which endangers the control of scab.

Summary.

1. A brief description is given of the types, properties and applications of a number of sulphur-containing sprays.

2. It is shown that in U.S.A. these sulphur products are used mainly for inclusion in a long series of post-blossom arsenical sprays.

3. The few published results of trials in England indicate that the sulphur pastes and powders are somewhat inferior to lime sulphurs yielding equivalent suphur deposits. While lime sulphur is usually more phytocidal, the other sulphur products do not obviate spray damage.

The assistance of Mr. E. H. Wilkinson in carrying out the field trial with ammonium polysulphide is gratefully acknowledged. Materials have been kindly provided by the following firms :— Messrs. Technical Products, Messrs. Lunevale Products, and the Camden Coke Co. (U.S.A.)

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SPRAY INJURY STUDIES.

PROGRESS REPORT.—II.

THE EFFECTS OF TIME AND TEMPERATURE ON THE PRODUCTION OF HYDROGEN SULPHIDE DURING ATMOSPHERIC DECOMPOSITION OF LIME SULPHUR.

By W. E. BERRY.

The decomposition of lime sulphur wash in contact with atmospheric air has received considerable attention in the past. Goodwin and Martin (3) and later Hodgkiss *et al* (4) investigated the reactions involved with particular reference to the influence of added lead arsenate. More recently, Reckendorfer (5, 6) has studied the progress of decomposition when atmospheric air, pure oxygen and pure carbon dioxide respectively are passed through lime sulphur solution.

Attention has been focussed principally on the reduction in polysulphide content of the wash, since it is agreed that this is the primary fungicidal ingredient. Hydrogen sulphide, produced either by elementary sulphur in contact with living plant material or by the action of carbon dioxide on lime sulphur, has undoubted fungicidal properties, and the writer has recently drawn attention to the possibility that it may not be without importance in certain types of spray injury (2). It seemed desirable, therefore, to determine the rate of hydrogen sulphide production when lime sulphur wash is exposed to the action of ordinary air.

In these circumstances, the wash is subject to decomposition by both oxygen and carbon dioxide. The end products of the former process are calcium sulphate and sulphur, and of the latter, calcium carbonate, hydrogen sulphide and sulphur. The course of hydrogen sulphide production should therefore serve to indicate the relative intensities of the two processes.

Reckendorfer (5) states that since atmospheric air contains about 700 times as much oxygen as carbon dioxide, oxidation must predominate, but the greater solubility of carbon dioxide and the relative rates of reaction, should be taken into account. However, Hodgkiss *et al* (4) conclude, from the small amounts of hydrogen sulphide evolved when lime sulphur is stirred, that decomposition is primarily due to oxidation.

Experimental.

For the purpose of the present experiment, ordinary commercial lime sulphur was diluted with distilled water to make a 2 per cent. solution, of which 50 ml. were placed in a boiling-tube. Air from outside the laboratory was drawn through the solution in a stream of small bubbles at the rate of 20 litres an hour. The air was filtered through cotton wool plugs before and after entering the lime sulphur solution and was finally passed through 50 ml. of 0.6% zinc acetate solution to absorb the hydrogen sulphide. The zinc acetate was renewed every 15 minutes and the amount of absorbed hydrogen sulphide determined colorimetrically by conversion to methylene blue by the method of Almy (1).

In view of the importance of temperature in problems of spray injury, the experiment was carried out at four different temperatures, 0.5°C. 18.5°C. 25°C and 35°C, obtained by immersing the tube containing the lime sulphur in a constant temperature bath.

Results.

The data obtained are presented in Table I and Fig. 1. The

TABLE I.

Effect of Temperature on the Production of Hydrogen Sulphide from 2% Lime Sulphur Solution.

Period (15 min. units.)	0.5°C.	18.5°C.	25°C.	35°C.
1	.0064	.0708	.1204	.2240
2	.0356	.2328	.3592	.4082
3	.1180	.2479	.3306	.2961
4	.1502	.1227	.1550	.1468
5	.0775	.0852	.1127	.1543
6	.0652	.0617	.1213	.1710
7	.0588	—	.1192	.1816
8	.0579	—	.1367	.2118

change in the rate of hydrogen sulphide production with time may be taken as representing the resultant of two opposing tendencies. The rate of evolution of hydrogen sulphide increases rapidly with time, but after about 45 minutes the removal of sulphur compounds from solution by oxidation, effects an equally rapid decrease.

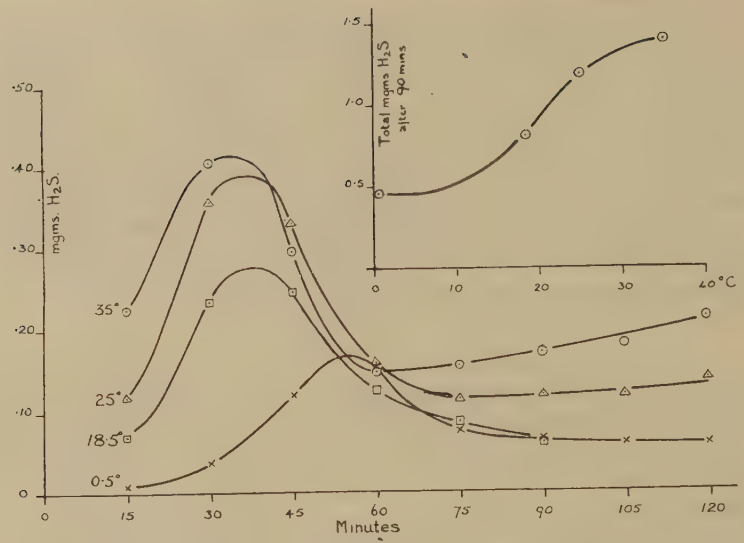

Fig. 1. The effects of time and temperature on the rate of hydrogen sulphide production by 2% lime sulphur during decomposition by atmospheric air.

Reckendorfer (5) observed that lime sulphur wash displayed considerable resistance to oxidation. He states that when air freed from carbon dioxide was passed through 120 ccs of 5% lime sulphur at 500 litres an hour, sulphur was not deposited until an hour after the start of the experiment. Pure carbon dioxide on the other hand decomposed the polysulphides completely in 6 minutes. In the present experiments, the time which elapsed before sulphur was deposited differed at different temperatures. but in all cases it occurred shortly after the evolution of hydrogen sulphide had reached a maximum.

It is concluded that on exposure of lime sulphur to air, decomposition by carbon dioxide begins almost immediately. Oxidation is retarded at first, but later predominates. As polysulphide and sulphide begin to be decomposed by oxygen, the amounts available for decomposition by carbon dioxide are rapidly reduced and the production of hydrogen sulphide falls off.

The amount of hydrogen sulphide which would be produced in the first 30 minutes, before oxidation becomes appreciable, may be calculated on the assumption that all the carbon dioxide which passes through the solution reacts to form hydrogen sulphide. Ten

litres of air pass in 30 minutes, containing .003 litres = 5.9 mgms of carbon dioxide. From the equation

$$CaS + H_20 + CO_2 = H_2S + CaCO_3,$$
$$5.9 \text{ mgms } CO_2 = 4.55 \text{ mgms } H_2S.$$

From Fig. 1 the actual amount of hydrogen sulphide produced in the first half hour was only 0.632 mgms at 35°C, at which temperature the reaction was approaching its maximum rate. Evidently only a fraction of the carbon dioxide reacts, which is to be expected from the rising rate of hydrogen sulphide production in the early periods.

The volume of solution used, 50 ml. contained 1 ml. of lime sulphur, with an estimated content of 5 per cent. monosulphide sulphur. This would be equivalent to 68 mgms of hydrogen sulphide if all the sulphide were decomposed by carbon dioxide. It is evident, therefore, that the reduction of hydrogen sulphide production after about half-an-hour is not due to exhaustion of the supply of sulphide and can only be due to the predominance of oxidation.

The slight rise in hydrogen sulphide production after an hour at the higher temperature may perhaps be due to a decrease in alkalinity and expulsion of dissolved hydrogen sulphide from solution. The solution still retained some yellow colour, however, indicating the presence of undecomposed polysulphide.

The effect of increasing temperature is to increase the rate of hydrogen sulphide production. The rates of oxidation, and decomposition by carbon dioxide are both increased, and the maximum rate of hydrogen sulphide production is thus reached earlier at higher temperatures.

From the data obtained it would appear that if hydrogen sulphide evolved from lime sulphur is a factor in spray injury, it will exert its maximum effect very shortly after the spray is applied. In practice, a much greater surface of solution will be exposed to the atmosphere than was the case in these experiments, and in some conditions the normal concentration of carbon dioxide in the air may be increased by the respiration of leaves. The former condition would no doubt accelerate decomposition, whilst the latter would tend to increase the production of hydrogen sulphide.

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A SIMPLE CONNECTOR FOR OVERLAND STEEL SPRAY MAINS.

By H. G. H. KEARNS.

Overland steel mains are extensively employed as a means of conveying spray washes to various parts of orchards or other crops. They are of particular value when the wash is pumped for considerable distances or several spray men are fed from the same pump. Long lengths of high-pressure rubber hose are best avoided because of the loss of pressure resulting from friction and elasticity of the walls of the tube, and in addition the hose is expensive and is often subject to bursts after two seasons' usage.

Steel mains are usually made up in lengths of 12–15′ and connected by short lengths of 12–15″ armoured rubber hose, fitted at each end with a cap and lining which screws on to bushes on the mains.

These rubber connections have become a frequent source of trouble during recent years due to the increased pressures used. Often the lining is forced out and this difficulty can only be overcome by holding the lining in the tube by binding the latter by means of very tightly strained, high tensile wire, a process that needs skill and special equipment. Alternatively a special type of hose connection must be used. Either method costs 17/- to 21/- per connection, and therefore it is a big item in the cost of steel overland mains.

Steel mains are moved from one position to another and therefore they must come apart and join together readily. In many instances, particularly on reasonably level ground, it is unnecessary to use flexible unions between the lengths of pipes, often only one or two being required in a total length of 300–500′. Most rubber connections have a standard form of cap and lining, the cap having two lugs on its rim to enable quick fitting to a bush on the end of the pipe.

A simple and cheap method of converting the caps into a metal connection has been devised and used successfully in long lengths of steel mains.

Description of the Metal Connection.

The majority of overland steel mains are of 1″ bore, but the linings of the coupling are $\frac{3}{4}$″ bore, and thus the volume capacity of the larger bored pipe is lost; similarly the constrictions in the passage of the cocks generally used render it wasteful in cost and weight to use more than $\frac{3}{4}$″ bore mains. For these reasons the following description of the metal connection refers to fitting to a $\frac{3}{4}$″ bore main.

The connection (see Plate I) consists of two main portions, a bush and a cap and lining.

(*a*) *The Bush* (Fig. 2).

The bush is a hexagonal nut bush of gun metal $1\frac{1}{4}$″ length. One end is provided with a hexagonal nut and the other with an external extra coarse thread. The nut portion is $\frac{5}{8}$″ length and is of Whitworth 1″ bolt head, dimensions ($1\frac{1}{16}$″ A.F.). It is bored and tapped for $\frac{5}{8}$″ depth with $\frac{3}{4}$″ B.S.P. thread and screws on to $\frac{3}{4}$″ B.S.P. galvanised steel main. The other end is $1\frac{5}{32}$″ external diameter and threaded with deep, quick thread 6 t.p.i. for a length of $3\frac{1}{2}$ threads; it is bored 1″ diameter for a depth of not less than $\frac{1}{2}$″, and the external face is finished flat, as it must fit accurately against a fibre washer on the lining of the cap.

(*b*) *The Cap and Lining.*

The Cap (Fig. 2). The cap is of gun metal $1\frac{5}{16}$″ external diameter by $\frac{9}{16}$″ and is cast with two lugs $\frac{9}{16}$″ round by $\frac{3}{4}$″ long on the opposite sides of the periphery. The cap is bored $1\frac{5}{16}$″ diameter for a depth of $\frac{7}{16}$″ and tapped with quick thread 6 t.p.i., the remaining depth being bored $1\frac{3}{32}$″ diameter.

The Lining. (Fig. 1). The lining consists of a standard $\frac{3}{4}$″ B.S.P. red steam barrel nipple, $2\frac{1}{4}$″ long and threaded both ends, and fitted with a gun metal collar on one end. The collar is conveniently made from a $\frac{3}{4}$″ B.S.P. gun metal connector $1\frac{1}{2}$″ long, which is cut into four equal lengths. One of these is screwed up to the end of the thread on one end of the barrel. It is then turned down in the lathe to $1\frac{1}{4}$″ diameter by $\frac{7}{32}$″ width. The thread of the barrel projecting beyond the collar is turned off to form a nozzle $\frac{5}{16}$″ length by $\frac{5}{16}$″ diameter. The two faces of the collar are cleaned up so that they are at right angles to the barrel. The lining is then passed through the aperture of the cap and screwed home into a connector on one end of the steel main by means of a narrow chain wrench.

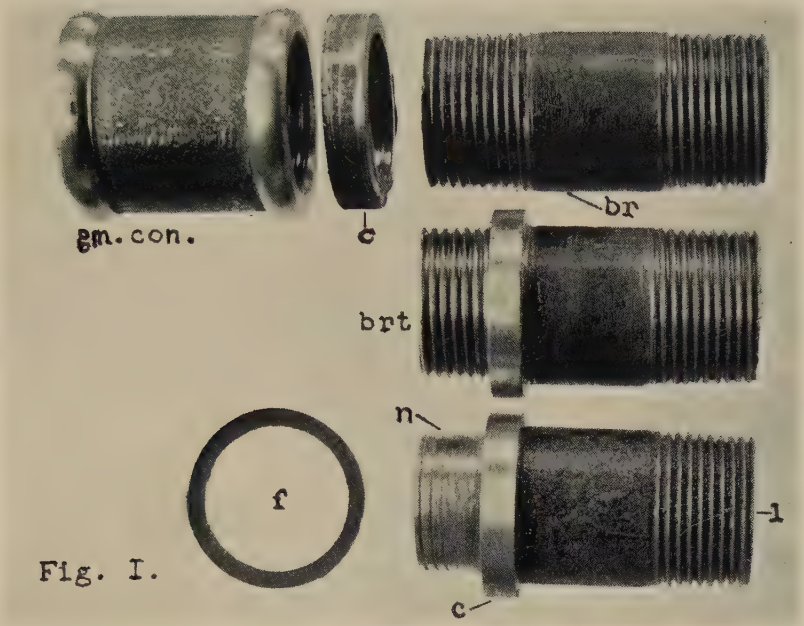

Fig. I.

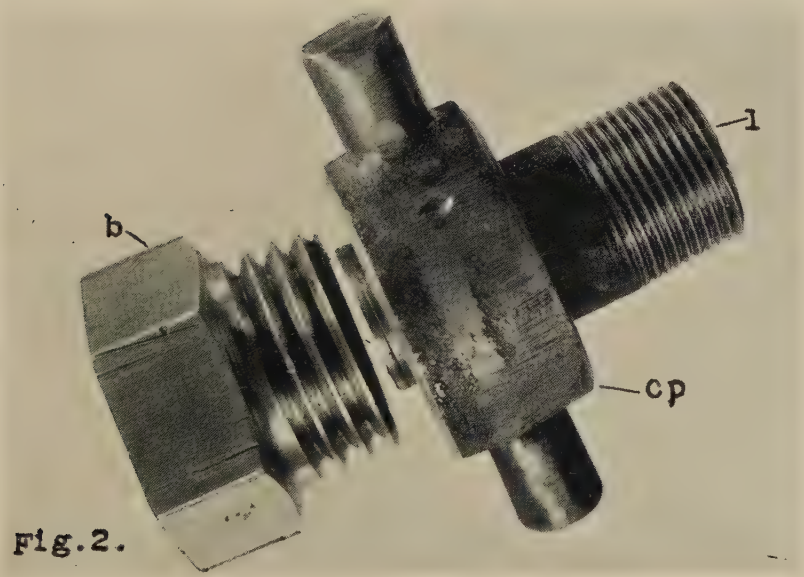

Fig. 2.

PLATE I.

Showing the Make-up of the Steel Main Connector.

Fig. 1, the component parts used in the manufacture of the lining. (*gm. con*) gun metal connector; (*c*) the gun metal collar; (*br*) the barrel; (*brt*) barrel with collar attached; (*f*) fibre washer; (*n*) nozzle formed by the removal of thread from the barrel; (*l*) the lining.

Fig. 2, the complete bush, cap and lining. (*b*) the bush; (*cp*) the cap; (*l*) the lining.

Connecting the Pipes.

Each steel main has a bush on one end and a cap and lining on the other. A tight fitting fibre washer is forced on to each nozzle to ensure a perfect joint between each cap and lining and bush. The lengths of the mains are connected by pushing the nozzle of the lining into the bush end and tightening up the cap. The bush is best held by means of a 1″ Whitworth set spanner. The gap of the spanner is ground oversize across the flats by $\frac{1}{16}$″ to overcome difficulties in fitting under field conditions when dirt is usually present and the nut faces become damaged. The cap is tightened by means of a " C " spanner which fits over one lug.

It is desirable to have a few steel mains bushed both ends so that flexible connectors can be used when required.

The cost of converting existing caps of flexible connectors to the all-metal type for materials and labour amounts to 1/6.

THE CONTROL OF FRUIT TREE RED SPIDER MITE.

By H. G. H. KEARNS and H. MARTIN.

The Fruit Tree Red Spider Mite (*Oligonychus ulmi* Koch) has many host plants, including the apple and the plum. In the early days of commercial fruit growing, attacks were unrecognized or of little importance. The introduction of tar oil washes and their general use led to changes in the spring spray programmes and since then slowly but surely, Red Spider has established itself as a pest of first rate importance.

It is well recognized that the yearly applications of tar oil washes, without any spring applications of lime-sulphur, are almost invariably followed in two or three seasons by devastating attacks of Red Spider. The reasons for these rapid increases in the mite population are the subject of differences of opinion, but it is clear that the clean bark and vigorous growth that follows the use of tar oil washes provides very favourable conditions for the rapid reproduction of the mites. Variations of summer weather conditions do not appear to influence the degree of infestation to any material extent, and severe attacks occur in both wet and dry seasons.

The widespread capsid bug attacks, prevalent on apples some ten years ago, and the successful use of petroleum winter washes to control them helped at the same time to keep the attacks of Red Spider in check in many orchards, but as soon as the capsid bug attacks were reduced to reasonable proportions the expensive petroleum washes were omitted, and the nicotine in the petal-fall sawfly washes was relied upon to maintain an effective check on further increase. From the date of this change-over increasing infestations of Red Spider have been noted. The reason for this increase is that the petal-fall wash of nicotine and lime-sulphur is applied with two main objects, firstly to wet the flower trusses for the control of Apple Sawfly and secondly to give a reasonable cover of the foliage against Scab. But the method of spraying adopted to achieve these purposes does not in most cases wet sufficiently the under surface of the leaves on which the mites

feed. Consequently the mites are only partially controlled and a sufficient number survive to give rise to a severe infestation.

As successive yearly infestations reduce the vigour of the tree, the cumulative effects are of far reaching importance and an adequate control of the pest must therefore be maintained.

Brief Life History of the Mites.

There are two main generations of the mites in a year. Reddish-coloured eggs are laid in large numbers on the second year and older wood of the tree in late July and August, usually in the angle of bifurcation of the shoots. Such large numbers may be present that the bark appears reddish in colour and at times numbers die during winter and lose their colour. This loss of colour does not necessarily mean death as it occurs naturally in viable eggs from January to March. As soon as the eggs are near hatching they become a conspicuous red. Some hatch from the end of the second week in April until the end of May, but in most seasons the maximum hatch occurs in the first ten days of May. This period of optimum hatching may occur either before or after the full pink-bud stage of mid-season flowering varieties such as Worcester Pearmain, Lane's Prince Albert, Bramley's Seedling and Cox's Orange Pippin, a fact that influences at times the degree of control obtained from lime-sulphur washes applied against Apple Scab. The mites, after hatching, assemble in very large numbers on the small leaves of the blossom trusses and remain there for about a week. As the cell sap becomes exhausted, the mites slowly wander to fresh feeding sites fairly near the original ones. By petal fall of the mid-season flowering varieties, a few mites may have become adult and laid eggs, but this stage is not generally reached until about ten days after petal fall when most of the mites wander, lay eggs on the lower surfaces of the leaves and die. The eggs hatch within two weeks and the resulting mites reach maturity by the end of July. It is this second brood that causes such extensive and insiduous loss of sap from the foliage at a period when it is urgently required by the tree. In some seasons mites may be found in numbers until the end of September.

Recognition of Red Spider Infestations.

The winter eggs are readily seen on apple trees especially at the end of March on the smooth bark of two-year or more old wood, and often occur grouped in thousands and generally at the base of

branching shoots. The habit of the mites of congregating at the full blossom stage of mid-season flowering varieties on the lower surface of the small leaves of the blossom trusses or of the small early basal leaves on the shoots and spurs, permits an estimate to be made of the probable degree of an infestation ; thus, if all the small leaves bear many mites, the infestation will be severe, but if the mites number only about six per leaf a serious attack is unlikely. Later, at petal fall, the presence of a few mites on normal leaves indicates that a severe infestation may develop later in the season.

From late June the first symptoms of infestations are patches of yellowish-green foliage in the trees, which subsequently extend over the whole trees. The foliage finally assumes a characteristic slightly silvery, brownish-green colour and the leaves are rather stiff to the touch. Numerous eggs, egg shells and mites may then be found on the under-sides of the leaves. The attack is more noticeable on trees that are suffering from nitrogen shortage.

The symptoms of attack on plums are somewhat similar, but the winter eggs are more evenly distributed over the wood than in the case of the apple.

Control Measures.

Control of Red Spider may be obtained by killing either the winter eggs or the spring brood of the mites before they have laid their summer eggs.

The Use of Winter Ovicides.

The eggs are killed by means of petroleum oil emulsions conforming to the specifications E or G (4). A concentration of not less than 3.0% oil (approximately 4% of many proprietary concentrates) is necessary to kill the eggs, but it is generally advisable in practice to increase the concentration to 5.0% oil (approximately $6\frac{1}{2}$% of many proprietary concentrates), as this higher concentration also provides a control of capsid bug and Winter Moth eggs. The oil is effective if used alone or in combination with tar oil or dinitro-ortho-cresol or dodecyl rhodanate or B-butoxy-B-thiocyanodiethyl ether.*

* The toxic ingredient of a material known as Lethane in the U.S.A.

The various winter washes should be applied at the following concentrations :—

Tar-petroleum Oil Wash.

Grade A tar oil	3.0%
Grade E petroleum oil	5.0%

Many proprietary washes at 10–11% dilution provide these concentrations of oils.

Dinitro-ortho-cresol-petroleum Wash.

Dinitro-ortho-cresol	0.1%
Grade E petroleum oil	5.0%

Approximately 8.0% dilution of some proprietary washes.

Lauryl-rhodanate petroleum Oil.

Lauryl-rhodanate	0.4%
Grade E petroleum oil	5.0%

B–butoxy–B–thiocyanodiethyl ether-petroleum Oil.

B–butoxy–B–thiocyanodiethyl ether ..	0.225%
Grade E petroleum oil	5.0%

(*I*) *Apples.*

The emulsions generally provide a high control of the eggs if applied from mid-December until just before the eggs hatch in early April, the most certain results being obtained from washes applied just before and after bud burst. For entomological and economic reasons the straight oil emulsions are best used just before bud burst while oil sprays containing other insecticides, *e.g.* dinitro-cresols or thiocyanate, should be applied up to two weeks before bud burst, namely, about mid-March in average seasons.

(*II*) *Plums.*

In plantations in which the Plum Sawfly (2) is not a pest of any importance the expense of applying a special wash against Red Spider at the post-blossom stage may be avoided by the use of a dinitro-cresol-petroleum or thiocyanate-petroleum winter washes at the concentrations recommended for apples. These winter washes must be applied not later than the end of January.

The Use of Petal-fall Contact Washes.

The mite in its active stages is readily killed by lime-sulphur, rotenone-containing materials and petroleum oil contact washes. The summer eggs and the moulting nymphs are not killed by lime-sulphur, *Derris* or *Lonchocarpus*; nor are high percentages of the summer eggs killed by petroleum oils applied at concentrations safe to foliage, namely, up to 0.67% of oil.

On apples, after petal fall, the mites are to be found on the lower surfaces of unfolding and expanded leaves, where they are protected by the leaf hairs which are difficult to wet. The washes must penetrate this hairy covering to wet the mites and the lower leaf surfaces completely. This is attained by the addition of wetters to the washes and the adoption of a special spraying technique.

The most certain kill of mites can be obtained when they have recently hatched from the eggs and have congregated on the small blossom leaves as previously mentioned. Unfortunately this period often coincides with the full-blossom period of many varieties and is too early for the application of the insecticides applied at petal fall. In some seasons a proportion of the eggs have hatched at the full pink-bud stage in which circumstance the application of the normal lime-sulphur wash for the control of Scab incidentally kills a number of the mites, even if a wetter is not added, as the small leaves are relatively easily wetted.

The mites are more easily killed on plums than on apples because the lower surfaces of the leaves are more easily wetted and the more open habit of growth permits the spray to penetrate the foliage better.

The following washes applied at petal fall provide a control of Red Spider :—

(*I*) *Apples.*

(i) *Sulphur-resistant Varieties.*

8 oz. nicotine (95–98%).
1–1½ gall. lime-sulphur.
½ lb. Agral II, or Lethalate Wetting Preparation or Sulphonated Lorol, or 2 pints Shell B sulphonates.
Make up to 100 gall. with water.

(ii) *Sulphur-shy Varieties.*

8 oz. nicotine (95-98 %).
1 gall. petroleum oil emulsion (0.67 gall. Grade G oil).
Make up to 100 gall. with water.

(*II*) *Plums.* At a period that coincides with splitting of the "cots" for two-thirds their length.

(i) *In the absence of Plum Sawfly.*

(*a*) (See Winter Ovicides, page 93).

(*b*) 1 gall. lime-sulphur.
$\frac{1}{4}$ lb. Agral II, or Lethalate Wetting Preparation or Sulphonated Lorol, ot 1 pint Shell B sulphonates.
Make up to 100 gall. with water.

(ii) *Plum Sawfly also a Pest.*

1 gall. petroleum oil emulsion (0.67 gall. Grade G oil).
Rotenone-containing material in amount sufficient to give 0.004% crystalline rotenone in the wash.
Make up to 100 gall. with water.

Modifications of the spray programme for apples and plums have been suggested. (3).

Methods of Spraying.

Drenching applications of the winter washes must be given so that the wood is completely covered. Spraying should be carried out under weather conditions that ensure a rapid drying of the wash on the bark.

The petal-fall applications must be carried out in such a way as to ensure that the *lower leaf surfaces are completely wetted.* If any difficulty is experienced with regard to wetting it will usually be overcome by increasing the amount of wetter used. The use of upturned nozzles or lances is preferable to straight nozzle spray guns for spraying small and medium-sized trees. This method of spraying apples at petal fall is entirely satisfactory for the control of Apple Sawfly, because the wash from the upturned nozzles falls on the fruitlets.

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FIELD TRIALS FOR THE CONTROL OF THE CABBAGE ROOT FLY, 1937-1939.

By C. L. WALTON.

Introduction.

Injuries caused by the maggots of the Cabbage Root Fly, *Delia* (*Hylemyia*) *brassicae* Bouché, constitute one of the most serious causes of loss to growers of Brassica crops, in particular of Cauliflowers and Brussels sprouts. Gardens and allotments are especially liable to attack whilst the extensive plantings in the Evesham area and elsewhere also suffer.

Considerable progress has recently been made in the control of this pest, and the writer has carried out a series of field trials during the past three seasons in order to test and demonstrate certain of these methods.

The Insect and its Life History.

The adult fly is ashy grey in colour, the female being from 5 to 7 mm. in length ; it commences to appear at the end of April and early in May. White cylindrical eggs are laid either upon or near the stem of the host plants, generally a number together, and these hatch in from four to seven days. The cream coloured and legless larvae pass through the soil and attack the younger roots, tunnelling in and destroying them, and even reaching the stem. Feeding continues for about three weeks when the larvae attain a length of about 8 mm. and pupation is in the soil, the pupal case being reddish-brown in colour. The second brood of flies is on the wing about the end of June and, under favourable conditions, a third may be produced. Winter is passed in the pupal stage.

Nature of the Damage.

All brassica crops are liable to attack, the main symptom of which is wilting of the foliage, which also shows a blue hue and later turns yellow. Growers frequently confuse the symptoms with those produced by the " finger and toe " disease, and the two troubles may occur together. Lightly attacked plants may form

fresh roots under favourable conditions, but the resultant crop is always affected adversely. Crops may be seriously infested whilst still in the seed bed. Attack is usually sporadic and may affect over 50% of a total crop.

Control Measures.

Numerous methods of control have been advocated, such as the application of " deterrents " like naphthalene, creosote and other substances, which confer some degree of protection.

Much more successful is the application of solutions of corrosive sublimate to the seed beds and about the stems of the plants after setting out. This method, however, owing to the trouble involved in making several applications of a poisonous fluid to a crop has never achieved wholesale adoption.

More recently the use of calomel has been tried in varying forms, and a 4% dust used once or twice after setting out the plants offers a more readily applicable, less poisonous, and, at the same time, reasonably successful method. The following notes relate the writer's experience with calomel in a series of field trials carried out during 1937, 1938 and 1939 in the Bristol Advisory Province, and also refer to unsuccessful trials with a solution of chloric acid.

Experimental.

I. Trials with Calomel.

Dr. Hugh Glasgow, of the New York State Agricultural Experiment Station, Geneva, New York, during a visit to Long Ashton Research Station, first drew the writer's attention to his experimental work with this substance for the control of root fly larvae. He subsequently supplied details (1) on which trials could be based, and the writer commenced by using a calomel suspension applied about the plants. Meanwhile D. W. Wright obtained excellent results at Cambridge using a dust containing 4% calomel (2). The advantages of the latter substance were so obvious that subsequent trials were made with it.

A. Field Trials in 1937.

Following numerous complaints of serious damage, trials were carried out at two centres in the Evesham district using applications of a suspension at the rate of 8 oz. of calomel to 60 gallons of water, to sprout crops. At one centre $\frac{1}{4}$ acre plots were treated on June 17th and July 7th and at the other seed beds were treated. Un-

fortunately 1937 proved to be a year of unusually light infestation and no attack developed in either case.

B. Field Trials in 1938.

Four trials were laid down at Lenchwick, near Evesham, all on sprouts. The same methods were followed as in 1937 but prolonged drought delayed application far beyond the intended dates.

(*a*) *Trial I. Heath Field, Lenchwick.*

6 acres of Brussels sprouts (totalling 24,000 plants) were used.

The treated areas comprised two blocks each of 9 rows, and each comprising between 2,600 and 2,700 plants (or 5,300 plants out of 24,000).

The field was set out on June 14th and owing to drought the trial areas were not treated until July 4th and 5th, when approximately $\frac{1}{4}$ pint of suspension was applied about the base of each plant. Only one application was made.

These plots were examined on August 4th and counts made on August 19th, when the following figures were obtained :—

Treated plots	.. ..	4.7% badly infested plants.
Rest of field	.. ..	16.6% „ „ „

This represented a saving of 12% or 480 plants per acre, which equalled the total produce of about $\frac{1}{8}$ acre.

These results were considered to be satisfactory in view of the very adverse conditions.

Similar trials were set out in three other fields in the vicinity but, in these, infestation was either absent or so very slight as to render counts useless.

C. Field Trials in 1939.

Trials were carried out at Lenchwick and Norton, nr. Evesham, and at Long Ashton.

Trial I. *Norton, near Evesham.*

Area, 4 acres. Sprouts set out May 15th.

The entire area, with the exception of 8 consecutive rows totalling approximately $\frac{1}{4}$ acre, was treated with a 4% calomel dust on May 18th and again on June 1st.

The blocks were: (1) $1\frac{1}{4}$ acres treated.
(2) $\frac{1}{4}$ acre control.
(3) $2\frac{1}{2}$ acres treated.

This field had a history of severe infestations. The untreated rows were practically ruined by a very severe infestation of *D. brassicae* and presented a most striking contrast to the rest of the crop.

Counts of randomized groups were made on 20/9/39, only obviously infested plants being included.

(*a*) *Control*:	Infested plants	300
	Healthy plants	100
		400
(*b*) *Treated areas*:	Infested plants	160
	Healthy plants	950
		1110

Trial II. Lenchwick, near Evesham.

Area $5\frac{3}{4}$ acres. Sprouts, set out on May 1st.

(*a*) 12 rows untreated.
(*b*) 19 rows dusted with a 4% calomel dust on May 3rd and 18th.
(*c*) The rest of the field remained untreated.

Counts were made 20/9/39, only plants obviously attacked being recorded.

(*a*) *Control*:	Infested plants	111
	Healthy plants	121
		232
(*b*) *Treated rows*:	Infested plants	184
	Healthy plants	568
		752

Trial III. Lenchwick, near Evesham.

Area 3 acres. Savoys, set out on June 14th.
$\frac{1}{4}$ acre dusted with calomel on June 17th and 28th.

No infestation occurred.

Trials at Long Ashton.

1. A small trial was carried out on a local market garden. Cauliflowers, set out June 26th. Total plants in trial numbered 405, set in 5 approximately equal rows. Rows 2 and 4 were treated on June 30th with a 4% calomel dust. Only one application was made owing to very wet weather and a heavy growth of weeds.

Control, at count totalled 237 plants :	Infested	74
	Healthy	163
Treated rows, 168 plants :	Infested	4
	Healthy	164

2. The importance of dusting as early as possible after setting out was exemplified in a batch of 80 cauliflower plants set out 22/5/39 in a private garden in Long Ashton and not treated until the 28th. These plants suffered a heavy infestation.

II. Trials with Chloric Acid.

A reference to the use of chloric acid for the control of *D. brassicae* in the U.S.S.R. was made in an article (3) which appeared in "Nature" in April 1938 in these terms: "Another somewhat unfamiliar insecticide is chloric acid, used as 0.1% solution for the destruction of the eggs of the cabbage flies *Phorbia brassicae* Bch. and *P. florealis* Fell." It was stated to have been used at the Plant Protection Station for the Leningrad Province and the Field Station at Peterhof.

Since enquiries made direct to these Stations failed to elicit any reply, preliminary trials were commenced in 1938 but were too late to do other than demonstrate that solutions at the strength stated and also at 0.2% did not harm the foliage of brassica plants nor injure newly set out plants when applied about the stems, and that such treatments, if successful, would be much cheaper than the methods then in use.

Field Trials in 1939.

A series of plantings of cauliflower were set out at Long Ashton Research Station on land known to be liable to heavy infestations, alternate rows being treated by pouring approximately $\frac{1}{4}$ pint of a 0.1% solution of chloric acid about the base of each plant.

All plants were subsequently raised and the roots examined.

Batch 1. 182 plants, set out April 25th. Treated May 3rd and raised for examination on July 5th.

This batch experienced very wet and sunless conditions and escaped infestation.

Batch 2. 220 plants, set out May 22nd, treated May 24th. 193 plants raised on July 5th.

Control: 92 plants. 60 infested.
Treated: 101 plants. 55 infested.

Batch 3. 285 plants, set out June 21st, treated June 22nd and raised on July 11th.

Control: 144 plants. 120 heavily infested.
Treated: 126 plants. All heavily infested.

A fourth batch was subsequently set out on the same land and alternate rows treated with a 4% calomel dust, but the whole remained uninfested.

Summary and Conclusions.

1. Applications of a calomel suspension gave hopeful results even when only one application, greatly delayed by drought, was made.

2. A high degree of protection was obtained in field trials near Evesham and at Long Ashton by applications of a 4% calomel dust to both sprouts and cauliflowers. Evidence obtained points to the importance of such applications being made as soon as possible after the plants are set out, especially during sunny weather.

3. Chloric acid, applied soon after setting out, at a strength of 0.1%, failed to give protection. The procedure followed was that in use for corrosive sublimate.

Acknowledgments.

The writer wishes to thank Messrs. S. Byrd & Son for valuable and competent assistance in carrying out the field trials near Evesham, and Messrs. Yeo in respect of similar help at Long Ashton.

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EXPERIMENTS ON THE CONTROL OF THE CHAFER BEETLE *PHYLLOPERTHA HORTICOLA* L. IN GRASSLAND.

PROGRESS REPORT.—I.

By S. H. BENNETT.*

Introduction.

The larva of the chafer beetle *Phyllopertha horticola* is a most serious pest in old grassland throughout the Bristol Province. In some localities infestations may be found in nearly every pasture in a district of several square miles in extent. The damage consists of a direct loss of hay or pasture herbage at the time of an attack, and subsequently of more serious loss in the quality of the turf due to the development of coarser kinds of grasses. During the past few years attacks of the chafer beetle have become more widespread and the control of the pest has thus become a matter of considerable importance to the farmer.

The application of naphthalene (3) has been the only method of control that has shown any measure of success, but the results have been inconsistent, and for this reason investigations of the biology of the beetle and methods of control have been undertaken. In view of the urgent need for data the preliminary results of the experiments are given in this article.

The insecticidal values of naphthalene, para-dichlorobenzene, ortho-dichlorobenzene, carbon bisulphide, dodecyl rhodanate and B-butoxy-B′-thiocyanodiethyl ether preparations have been tested as means of killing the larvae but none of these materials, used at economic or safe concentrations, have proved satisfactory.

It would appear at the present time that in districts subject to infestation ploughing in the turf for arable cropping offers the most satisfactory solution of the chafer problem.

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Detection of Infestations.

Grassland on the lighter, well-drained soils is most subject to attack, particularly meadows that are left rough or not mown or grazed until late in the season. Often the first symptom of an infestation to be noticed is the presence of birds tearing up the grassland in hunting for the grubs. In other cases the bird damage does not occur to any extent and the attack is manifested in a characteristic spongy feeling of the land caused by the grasses and other pasture plants losing their roots. The turf in September is very easily removed by pulling, and later, in such cases, large dead patches appear. In a serious attack the number of larvae may be as large as $1\frac{1}{2}$ millions per acre. The population necessary to produce obvious symptoms of damage varies considerably and depends largely on the nature of the pasture. A thin pasture may be rendered bare by a population that would not produce very obvious symptoms of attack on good land.

The infestation in some instances may only occur for one or two years, but usually the attacks become progressively worse over a period of years and extend to neighbouring grassland. The depreciation, although difficult to assess, is often considerable and is reflected in the reduced stocking capacity of the land.

Brief Life History of the Beetle.

The adult beetles emerge from their pupal cells in the ground at the end of May and early June, and the flight period is of about one month's duration. They feed on the foliage of deciduous trees, various broad-leaved weeds and young bracken. Pairing takes place on bright sunny days and flying occurs mainly on warm evenings. Dark wet days restrict movements. Oviposition commences 10—15 days after emergence and the females burrow into the ground and deposit the eggs at 1 to 2 inches below the surface. The beetles die in numbers in the soil.

The eggs hatch in 15—20 days and the first instar, which is eruciform, is of 19—25 days duration, during which period it feeds and moves very little. The second stage larvae feed voraciously for 3 to 4 weeks and then moult into the last stage which are fully fed by the beginning of November. With the onset of lower soil temperatures the larvae descend slowly to a depth of 7 or more inches in the soil so that they are protected from all normal winter conditions. Even the prolonged frost in January and February 1940, when the soil at 8″ depth was frozen for 28 days, failed to

produce a high kill of larvae in all soils. In late April the larvae move upwards in the soil and pupate in earthen cells at 4—6″ depth below the surface. The pupal period lasts for about a month.

Experimental.

(A) Small Plot Trials.

In experiments to determine the toxicity of a number of insecticides to the larvae, under controlled conditions, a method was evolved in which the larvae were kept under conditions similar to those which normally occur in the field. A piece of grassland on a fairly light soil was divided up into areas of 3′ x 2′. Each area was enclosed in a wooden-sided cage sunk in the soil to the depth of 14″, which was sufficient to prevent the escape of chafer larvae. The cages projected three inches above the soil and were covered by wire netting to prevent any interference from birds. One hundred 2nd instar larvae of similar ages were introduced into each cage at the end of August 1939. These settled down quickly and in a few days were feeding voraciously on the grass roots. The larvae were allowed to remain undisturbed for three weeks, after which various insecticides were applied. Amongst materials tested were the following :—

(*a*) Whizzed naphthalene. Grade 16 material was broadcast at the rates of 2, 4 and 8 cwts. per acre.

(*b*) Paradichlorobenzene-naphthalene emulsion. The emulsion was prepared by dissolving 1 lb. of paradichlorobenzene, 4 lb. Grade 16 naphthalene in 1 gallon kerosene (1), and emulsifying the solution with 20 per cent. sulphite lye (2) to give an emulsion containing 33 per cent. of the kerosene solution. The emulsion was applied at concentrations equivalent to $\frac{1}{4}$, $\frac{1}{2}$ and 1 cwt. of paradichlorobenzene and 1, 2 and 4 cwt. of naphthalene per acre.

(*c*) Carbon bisulphide-naphthalene emulsion. A saturated solution of Grade 16 naphthalene in carbon bisulphide was emulsified with an equal volume of 20 per cent. sulphite lye solution. It was applied at concentrations of 0.16, 0.32 and 0.64 per cent. naphthalene.

(*d*) Orthodichlorobenzene emulsion. A 50 per cent. emulsion was prepared with 20 per cent. sulphite lye. It was applied at concentrations of 0.16, 0.48 and 1.28 per cent. of orthodichlorobenzene.

(*e*) Dodecyl rhodanate emulsion (2). A 33 per cent. emulsion was prepared with 20 per cent. sulphite lye solution. It was applied at 0.16, 0.48 and 1.28 per cent. of dodecyl rhodanate.

(*f*) B-butoxy-B′-thiocyanodiethyl ether emulsion*. A 33 per cent. emulsion was prepared with 20 per cent. sulphite lye solution. It was applied at 0.3, 0.75 and 1.50 per cent. of the active constituent.

Experiments on methods of applying the soil insecticides showed that the most consistent results were obtained by keeping the length of grass down to 2″ and thoroughly watering the plots one hour before treatment. In the case of solids the material was evenly broadcast and then watered in with ½ gall. water. The emulsions were applied at the rate of ½ gallon per plot.

The larvae were carefully recovered three weeks after the treatments. The principal results were as follows :—

TABLE I.

Showing the Percentage Kill of Larvae.

Substance.	Rate per Acre or Concentration.	% of larvae killed.	Damage to Grass.
Naphthalene	2 cwt.	12	No damage.
,, ...	4 cwt.	45	,,
,, ...	8 cwt.	60	,,
Paradichlorobenzene naphthalene emulsion	4 cwt.	75	,,
CS_2 naphthalene emulsion ..	0.64 per cent.	80	,,
Orthodichlorobenzene emulsion	0.48 per cent.	45	Slight.
	1.28 per cent.	100	Very severe.
Dodecyl rhodanate	1.28 per cent.	50	No damage.
B-butoxy B′-thiocyano-diethyl ether	1.0 per cent.	50	Severe.
	2.0 per cent.	85	Severe.
Untreated		5	

(B) Field Trials.

Trials with naphthalene were carried out over two seasons, the material being applied under conditions similar to those in the small plot trials.

* The active constituent of a preparation sold as Lethane in U.S.A.

A 12 acre pasture was top-dressed in mid-October with 2 cwt. per acre of whizzed naphthalene by means of a seed drill. At the time of treatment the larvae were in their third instar and near the surface. Rain fell three days after the application. Randomised blocks, each 1 sq. ft. in area, were examined during late autumn and again in May. It was found that only 20 per cent. of the larvae had been killed. In the following season the same pasture was treated in mid-September just before rain, with the same amount of naphthalene. This second application killed 30 per cent. of the larvae.

Conclusions.

None of the insecticides tested were sufficiently toxic at economic or safe concentrations.

Until a satisfactory method of controlling the pest in turf is discovered, the most economic procedure is to plough the infested pasture in September in order to expose the maximum number of larvae to the birds. Grassland on types of soil subject to regular infestation should be restricted to short leys of not more than seven years' duration.

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A NOTE ON THE CADDIS-FLY, *LIMNOPHILUS LUNATUS* CURTIS, AS A PEST OF CULTIVATED WATERCRESS.

By C. L. WALTON.

During the first week of April 1939 requests for information were received regarding injuries to a series of small beds of cultivated watercress in North Somerset and an extensive planting in Wiltshire.

Both cases were investigated and the beds were found to be swarming with larvae of a Caddis-fly. A considerable number were reared in the laboratory and lived satisfactorily in large glass vessels, the water of which was changed every few days, until a few days of hot weather in early August when the majority died. Fortunately one specimen hatched out during early September and was kindly identified by Dr. F. J. Killington.

Nature of the Damage.

The damage consisted in extensive destruction of foliage to form the larval dwelling case and as food, and the stems were also eaten away to a considerable extent, more especially as the larvae increased in size.

There was evidence that some frost injury had been experienced during the winter in both the localities examined, and this had undoubtedly weakened the plant growth, whilst a further factor was the presence of large numbers of water snails about the roots, chiefly *Limnaea pereger* and *L. palustris*. In some cases the beds were so decimated that extensive bare patches occurred, whilst in others detached stems drifted and floated together in masses; all swarmed with larvae.

The writer considers that although the loss of foliage due to the presence of the larvae was extensive it would have been much less apparent in the absence of the weakening of the usual dense growth by frost. There is no doubt, however, that these larvae are capable of causing very extensive injuries. It was stated that frost had not affected these beds for about 40 years. The larvae showed a

preference for pieces of green leaf for case construction, but used pieces of stem and other materials when leafage ran short, and especially as they increased in size.

Mr. A. S. Buckhurst, M.B.E., of the Ministry of Agriculture, informed the writer that he investigated a similar case in Sussex some years ago.

Control Measures.

As regards control, in the case of the smaller beds in North Somerset, the snails were first destroyed by the use of very dilute solutions of copper sulphate (which also killed many leeches and worms) and the larvae were then killed by means of Derris, also used in great dilution. It was impossible to estimate the exact rotenone concentration of the Derris dressing since most of the pools were fed by springs rising from their beds, whilst the outflow also could not be fully controlled, but a concentration of 0.001% was aimed at. The larvae, however, were eliminated, and the owner reported later that the beds were clear of all pests and were being restocked.

These cases are reported since it is evident that Caddis-fly larvae are capable, under certain conditions, of causing extensive defoliation to cultured watercress beds.

It is most important that neither copper sulphate nor Derris should be used if there is any chance of water treated with these substances entering any stream or body of water containing fish, as both are extremely poisonous to fish life.

POT EXPERIMENTS ON BITTER PIT OF APPLES.

By T. WALLACE and J. O. JONES.

The experiments summarised in this paper were commenced in March 1928 when 45 apple trees, variety Bramley's Seedling, on Malling No. IX rootstock, were planted in a compost contained in plant pots—forty of 18″ diameter and five of 12″ diameter.

The initial objects of the experiment were to examine the incidence of Bitter Pit in relation to soil moisture and atmospheric temperature, and for this purpose the trees were divided into "high" and "low" soil moisture groups and some grown in a specially constructed orchard house and others in the open.

It was subsequently found impossible to grow the trees satisfactorily except under conditions of high soil moisture, and satisfactory comparisons between the "inside" and "outside" trees could not be obtained owing to frost and wind effects. It was clear, however, in these experiments that the pot culture method was well suited to the production of Bitter Pit as large proportions of the crops each year were affected by the trouble.

In view of this early experience, it was decided to use the trees for injection experiments with various chemicals as a preliminary to larger experiments in the field.

The materials injected have consisted mainly of salts of "minor" elements which appeared of special interest, and of a few salts containing calcium, magnesium, potassium and phosphorus, together with citric acid.

Since none of the treatments given appear to provide protection against Bitter Pit the experiments are reported as briefly as possible.

Materials and Methods.

Two sets of apple trees, variety Bramley's Seedling, have been used for injection experiments. The first set comprised 25 trees on Malling No. IX rootstock—20 in 18″ pots and 5 in 12″ pots—planted in March 1928, and used originally for high soil moisture treatment. Until the end of 1937, ten of the large pot trees were grown in the orchard house and ten outside during the growing season, all trees being housed in the orchard house over winter. The trees in the small pots were grown in the orchard house.

The second set consisted of 30 trees on Malling No. I rootstock, in 18″ pots, planted November 1935. These trees were grown in the orchard house during 1936 and 1937 and outside in 1938 and 1939. Each season the outside trees were removed from the orchard house into the open during May when the risk of spring frosts seemed small.

The compost used in the pots in both series consisted, by weight, of soil 20 parts, sand 10 parts, leaf mould 5 parts and wood charcoal 1 part. The compost when wetted to maximum water holding capacity in the pots contained 39 per cent. moisture.

Throughout the experiment the water content of the compost was kept near the maximum value by daily watering. The pots were placed on old railway sleepers and fitted into specially constructed wooden cases to protect the soil and roots from high summer temperatures.

In the older series the small pot trees were repotted into fresh compost in 1934 and those in the large pots at the end of 1937.

Each season a complete N. P. K. fertiliser was given to all pots, consisting of nitrate of soda or nitro chalk, superphosphate and sulphate of potash, the rates of nitrogenous dressing varying with the age of the trees. All the trees used have grown vigorously and have carried particularly large leaves. It has also been notable that where the trees have been grown in the orchard house the fruits have all been entirely green whilst those outside have been flushed with red. One effect of growing the trees outside, as compared with those inside, has apparently been to lower the

nitrogen status within the trees in spite of equality in nitrogenous treatment.

The method of salt injection used was essentially the Dry-Salt method recommended by Bennett (1) for injection of iron salts, the dosages for various salts being modified as under.

The minor elements, boron, zinc, manganese, copper, aluminium, nickel, cobalt, molybdenum, chromium, and lithium, were used in equivalent quantities, these quantities being calculated from the scale adopted for boric acid, which was based on one-seventh the weights of ferric citrate recommended by Bennett for corresponding sizes of stems. The major elements, potassium, magnesium and calcium, were also used in equivalent amounts in these cases, the basis of calculation being potassium chloride at twice the weights recommended for ferric citrate. Citric acid was used at the same rates as those given for ferric citrate.

The injections were made each season during March when the fruit buds were just beginning to burst, two or three trees being used as the unit for each treatment. The only appreciable damage from the injections resulted from cobalt and nickel, where burning of the leaves and dying back of the main branches occurred, in all cases the trees being almost killed. Slight leaf symptoms occurred from copper, aluminium and manganese on some of the young foliage early in the season but the effects later were negligible. Growth in all cases was vigorous following the injections, except for the trees injured by nickel and cobalt treatments. Where potassium phosphate was used the trees showed pronounced yellowing of the foliage towards the end of the season and the fruits were very highly coloured, the effects suggesting that the treatment brought about a relatively low nitrogen status in the trees.

Results and Discussion.

The results for Bitter Pit obtained during three seasons on the fruits harvested from the trees receiving the various injection treatments and stored under common farm storage conditions, without temperature regulation, are given in Table I. In assessing the amount of Pit each season, the fruits were kept until near the end of the storage life when every fruit was cut and examined.

TABLE I.

Showing the Percentages of Bitter Pit Developed in the Fruits of Injected Trees.

Year.	Special Treatment.	No. of Fruits Stored.	% Pit Developed in Store.	Remarks.
1936	Nil	100	64	Trees both treatments grown in orchard house. Crops very light.
	Boric Acid	15	60	
1937	Nil	40	43	Tress all treatments grown in orchard house. Crops light.
	Boric Acid, 1936, 1937	17	47	
	Zinc Sulphate ..	20	35	
1939	Potassium Sulphate ..	29	86	Trees all treatments grown in orchard house. Crops light, fruits large. Bitter Pit intensity severe all treatments.
	Potassium Chloride ..	23	88	
	Magnesium Sulphate ..	53	51	
	Magnesium Chloride ..	32	75	
	Calcium Sulphate ..	30	67	
	Copper Sulphate ..	27	93	
	Citric Acid	15	93	Trees in 12″ pots used these treatments.
	Calcium Nitrate ..	14	79	
1939	Aluminium Sulphate ..	20	65	Young trees all treatments and grown outside. Crops light.
	Copper Sulphate ..	25	76	
	Nickel Sulphate ..	1	100	
	Cobalt Sulphate ..	1	100	
	Molybdic Acid ..	30	73	
	Chrome Alum	27	70	
	Lithium Sulphate ..	31	35	Many small fruits this sample.
	Manganese Sulphate ..	25	64	
	Zinc Sulphate	30	87	
	Citric Acid	25	76	
	Magnesium Chloride ..	15	73	
	Magnesium Sulphate ..	24	67	
	Potassium Chloride ..	32	81	
	Potassium Sulphate ..	22	32	
	Di-Potassium mono-Hydrogen Phosphate	30	43	

In considering the results, no attempt should be made to compare critically the results for the different elements injected, since the numbers of fruits stored were too small to allow of this being done. The conclusion which can be drawn from the results is that Bitter Pit has been very severe in all cases and it thus seems highly improbable that any of the treatments can provide any appreciable

control of the trouble. Bitter Pit, in fact, does not seem to result from a deficiency of any of the elements used.

The treatments, using sulphate and chloride in conjunction with potassium and magnesium, were included to see whether the chloride ion was likely to promote Pit in these combinations more than sulphate and, although larger amounts of Pit always occurred in the chloride fruits in the comparisons possible, no definite conclusion can be drawn. A series of field plots have been laid down to test this point.

It may also be added that several field experiments have been carried out with boron injections, using the scale of rates employed in these pot experiments, and, at one centre, higher rates producing serious injury have been used. In all these cases boron has been without effect in reducing Pit, occurring either on the trees or during storage. Iron citrate has also been tried in the field without effect. Moreover, both boron and iron have been ineffective against "Cork" in pears, a problem requiring examination from the virus standpoint (2).

In the field trials with boron, chemical examinations* of the foliage and fruits of treated and untreated trees have shown that the injection treatments have substantially increased the boron contents of both of these, and that the amounts of boron in the foliage and fruits of the untreated trees appear adequate when judged by the standards of New Zealand workers. The latter fact strongly suggests that boron is in no way connected with the Bitter Pit problem, a conclusion also reached by workers in other countries.

Summary and Conclusions.

1. Injection experiments, using salts of various "major" and "minor" elements and citric acid, have been carried out on apple trees, variety Bramley's Seedling, growing in a compost in pots, to determine the effects of the various elements and compounds on the incidence of Bitter Pit.

2. Bitter Pit was severe under all treatments and it is concluded that the elements and compounds concerned are ineffective in controlling the trouble.

3. Of the elements used only cobalt and nickel caused appreciable damage to the trees.

* The chemical results will be reported later.

4. Field tests have also shown the ineffectiveness of boric acid and iron citrate in controlling Bitter Pit of apples and Cork in pears.

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NOTES ON THE INCIDENCE OF PLUM BACTERIAL CANKER IN RELATION TO METHODS OF PROPAGATION.

By R. W. MARSH and T. SWARBRICK.

In the West Midland plum growing districts the difficulties of marketing Yellow Pershore Egg Plums in a glut year are well known. At such times the demand is only for higher quality plums, such as Victoria, or for late varieties, such as Giant Prune. There is consequently a powerful motive for converting plantations of Pershore to one of these more desirable varieties, either by grubbing and refilling or by top-working. Both Victoria and Giant Prune are however subject to disease. Victoria is highly susceptible to Silver Leaf and both varieties are prone to Bacterial Canker.

Bacterial Canker has been extensively studied by Wormald and his co-workers at East Malling. In 1931 (2) he suggested the top-working of Victoria on resistant stem or framework-builders as a means of reducing losses, and in 1934 (3) recorded that trees of Victoria worked high on Common Plum or Myrobalan B were less liable to be killed by bacterial canker than those worked low. Low-worked trees on Brussels, Brompton, Common Plum and Myrobalan B were equally susceptible to canker. Montgomery and Moore (1) recorded that, of the varieties tested as stem-builders, Victoria, Denniston's Gage and Pershore suffered most severely from cankers; Warwickshire Drooper, President and Utility were resistant, and Purple Pershore and Myrobalan B remained unattacked.

Observations carried out in Worcestershire since 1928 have shown that in this area Giant Prune is the variety most susceptible to canker, losses up to 50 per cent. in young trees being not uncommon. Victoria is only a little less susceptible, but Pershore, although commonly attacked, is not girdled and killed as frequently as Victoria or Giant Prune. Tests of Pershore as a framework-builder therefore appeared to be justified on the basis of disease resistance as well as from economic motives. Observations were also carried out to determine rootstock effect on canker susceptibility in Victoria and Giant Prune low-worked as in ordinary

nursery practice, using the rootstocks Pershore, Myrobalan and Kentish Bush.

Stock Effect in Low-worked Trees.

Victoria plums were budded in 1931 or grafted in 1932 at Long Ashton on the following stocks: Pershore, Myrobalan B and Bush (Kentish Bush). In November 1933, 32 of these trees on Kentish Bush, 32 on Myrobalan and 6 on Pershore were set out in a newly-made Worcestershire plum plantation. Up to 1939 two of the trees on Myrobalan had been killed by canker; all the other trees were healthy. Those on Pershore stocks had made the best growth: Kentish Bush stocks gave slightly less vigour and the growth on Myrobalan was fair.

Fifteen Giant Prune trees were budded on seedling peach stocks in 1930 and used for refilling in 1931 in a neighbouring Worcestershire plantation where bacterial canker was abundant. Up to 1939 these trees had made fairly good growth, and only one tree had died.

Giant Prune was also budded or grafted in 1931–32 on Myrobalan, Pershore and Kentish Bush. These trees were set out in the same plantation in 1933, but in a separate row made up of 26 trees on Myrobalan, 24 on Kentish Bush and 19 on Pershore. Bacterial canker attack on these trees was relatively severe, the number of deaths up to June 1939 being as follows:—

Giant Prune on	Myrobalan (26 trees)	..	18	deaths.
,, ,, ,,	Pershore (19 trees)	..	6	,,
,, ,, ,,	Bush (24 trees)	..	1	,,

It is noteworthy that the highest percentage of attack was on the most vigorous trees—those on Myrobalan rootstock. The trees on Pershore were slightly smaller and those on Kentish Bush, although well grown trees, were markedly smaller than those on Myrobalan.

Stock Effect in Head-worked Trees.

The experiments in head-working were all carried out on trees of Pershore growing on their own roots. In April 1931, six seven-year-old trees growing in the plantation previously mentioned were headed back to 3—5 main branches which were top-worked with Giant Prune. Four of these trees made excellent growth: the other two died. Another series of four-year-old Pershore trees was top-worked in the same way on 31st March, 1931, and used for refilling in the following year. Out of eleven trees, one died, three

made fairly vigorous growth and the remainder formed excellent trees.

Head-working experiments were also carried out with Victoria top-worked on to four-year-old Pershore trees. Nineteen were used for re-filling in 1932, and twenty were set out in the new plantation in 1933. No deaths occurred, but the trees on both sites made somewhat straggling growth with rather thin foliage. This inferiority in vigour as compared with adjacent trees low-worked on Pershore was still well marked in 1939.

Conclusions.

The above results were not obtained from a specially designed experiment, but from observations on scattered units in a commercial fruit farm. For this reason, any conclusions drawn must be tentative, but the indications are as follows :—

1. In low-worked trees, Kentish Bush is a satisfactory rootstock for both Victoria and Giant Prune, and Giant Prune trees on this stock show marked resistance to bacterial canker.

2. Giant Prune top-worked on to young Pershore trees makes satisfactory growth, but top-working of Victoria on to Pershore gives a tree lacking in vigour.

Acknowledgments.

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CUPROUS OXIDE AS A SEED PROTECTANT FOR PEAS.

By L. OGILVIE, H. E. CROXALL and C. J. HICKMAN.*

Introduction.

Cuprous oxide has recently become popular in America as a seed protectant against "pre-emergence damping-off." By the latter term is meant rotting of seeds and failure of seedlings to emerge owing to attacks by soil organisms. Investigations in America have shown that many kinds of seeds are benefited by cuprous oxide treatment, and valuable results have been reported on peas. The present paper reviews briefly previous work on this subject and describes some greenhouse and field experiments illustrating the effects of the treatment.

Historical Survey.

In some seasons considerable loss is caused by failure of peas to emerge through the soil. This may possibly be due to the use of seed of low viability or to seed infected with disease-producing organisms. Frequently, however, it is caused by healthy seed being attacked by soil organisms before germination or before the seedlings reach the soil surface. Species of Pythium are regarded by a number of authors (3, 5, 10) as mainly responsible for the disease although other fungi, including species of Fusarium (4, 9, 15), Rhizoctonia (10), Mucor (3) and Botrytis (15) have been shown to be associated with it.

It is generally agreed that the incidence of the disease is dependent on environmental conditions. Haenseler (5), for example, found that in soils contaminated with Pythium a moisture content of 60-80% favoured complete rotting of the seed. Under drier conditions germination was improved. L. K. Jones (11) and Horsfall (7) made the interesting observation that the effect of high soil moisture content decreased the longer the interval between sowing the seeds and addition of water to the soil. The decreased emergence of pea seedlings under conditions of high soil moisture has

* This investigation was initiated by Dr. J. G. Horsfall during his stay at Long Ashton in 1936–37. C. J. Hickman co-operated in the early stages of the work.

also been noted by Hull (9). Little information is available on the effect of temperature alone, but Brett *et al.* (4) and L. K. Jones (11) indicate that germination is comparatively low when pea seeds are sown in cold and wet soils.

With regard to the susceptibility of different varieties to the disease, round seeded varieties are apparently more resistant than wrinkled ones. Thus L. K. Jones (11) observed that whereas the round seeded variety Alaska gave a percentage emergence of 75 under high soil moisture conditions that given by an unnamed wrinkled sort was only 44. Similarly, Hull found that the round seeded variety Pilot gave better stands than the wrinkled variety Gradus (9).

Cuprous oxide was first used as a protectant for pea seeds by Horsfall *et al.* (8) and subsequently by Anderson and co-workers (12). It has been stated (16, 17) that cuprous oxide is now employed very commonly in the United States, especially for canning varieties. The material is now also being used to some extent in England. It is suggested by Horsfall that its effect is to protect the seeds and probably, to some extent, the developing seedlings, from attack by soil organisms, resulting in an increase in the number of seedlings emerging. In greenhouse experiments Horsfall (7) and Kadow and Anderson (12) have recorded increases of from 2–50% in the stand of treated seeds. In the field the latter authors, and also Anderson *et al.* (1), have obtained increases in stand of from 30–68%, while in New York State, from 1935 to 1937, (16, 17, 18) increases in stand of from 4–30% were obtained, depending upon the season and variety of pea seed treated.

In addition to an increase in stand, it is also claimed by Horsfall *et al.* (8) that the rate of emergence of treated seeds in comparison with untreated ones is sometimes apparently accelerated, a result ascribed to freedom of the plants from disease.

On the other hand, under certain conditions cuprous oxide treatment appears to be injurious (17, 18). It is suggested (17) that drought, low soil organic matter content, soil acidity, and sowing of fertiliser with the seeds (18) favour cuprous oxide injury. Physical damage may also occur when treated seeds are sown by drilling machines owing to increased friction between the seeds. This latter effect has been overcome by adding finely powdered graphite at the time of dressing (2).

Horsfall (8) originally suggested the following specifications for cuprous oxide as a seed dressing: it should contain not less than 96% cuprous oxide; the colour should be bright red and should

not change on exposure to air, *i.e.* the material should not oxidise to cupric oxide, which has little protective value ; at least 97.5% should pass through a 325 mesh screen ; the material should " fume " when shaken up in a flask and should not collect into lumps ; lastly, when a small quantity is placed on a piece of white paper, which is slowly moved into a vertical position, enough should adhere for the paper to remain bright red. The best results were obtained with this material when it was added at the rate of 0.25% by weight of the pea seed. Anderson and his co-workers (1) later gave a similar specification, but found that equally good results followed the use of brown cuprous oxides provided that they also had a high degree of purity. They emphasized as essential that the material should give a smooth and uniform coverage to the seed. In their experiments they used excess of dust, removing that which did not adhere by screening. Heuberger and Horsfall (6) have recently shown that the efficiency of cuprous oxide increases with diminution of particle size and that this is correlated with its colour. Samples of relatively large particle size were red or purplish red in colour while samples of relatively small particle size ranged from orange to yellow. Associated with these differences in particle size and relative efficiency they have put forward evidence that the optimum rate of application is 0.5% by weight of seed for the red cuprous oxide and 0.25% for the yellow form.

Experimental.

Materials and Methods.

The sample of cuprous oxide used in the following experiments agreed with Horsfall's original specifications which have been given above. For greenhouse trials the seeds and cuprous oxide were placed in tightly stoppered Erlenmeyer flasks and shaken on a rotary shaker for 15 minutes at 36 r.p.m. The dosage was at the rate of 0.25% by weight of seeds. The seeds were sown in boxes measuring 14 × 9 × 2 inches. These were filled with soil, the top layer of which was then removed to a depth of 1 inch for sowing. The seeds were pressed into the soil level with the surface, after which soil was added to completely fill the boxes. Fifty seeds were planted per box and unless otherwise stated the boxes were watered immediately after planting. For field sowings, the seeds were treated, at the same dosage, in a churn fitted with baffle boards.

Greenhouse Trials.

Table I illustrates the effect of cuprous oxide on pre-emergence damping-off in four soil samples. Two of these, A and B, were

taken from two typical market gardens in the vicinity of Bristol. Sample C was a compost of loam and leaf mould commonly used in the greenhouse of the Station, while D was the same greenhouse soil artificially contaminated with *Pythium ultimum* after sterilisation. This fungus had previously been isolated from decaying pea seeds removed from unsterilised greenhouse soil. Sample E was sterilised greenhouse soil. The variety used was the wrinkled seeded Surprise.

TABLE I.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED SEEDS IN VARIOUS SOIL SAMPLES.

Treatments.	Soil Samples.				
	A	B	C	D	E
Cuprous oxide ..	78	85	72	11	—
Untreated ..	13	33	3	0	92

In all cases the emergence of the treated seeds was much higher than that of the untreated. The high germination of untreated seeds in sterilised soil shows clearly that its poor germination in the other soils was not due to the effects of seed borne organisms. The results also show that *P. ultimum* is evidently important as a causal organism of pre-emergence damping-off.

Further experiments with several varieties sown in unsterilised greenhouse soil gave essentially similar results. Some of these are given in Table II.

TABLE II.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED SEEDS OF VARIOUS VARIETIES OF PEAS.

Varieties.	Treatments.							
	Cuprous Oxide.				Untreated.			
Round Seeded.	Expt. 1	Expt. 2	Expt. 3	Expt. 4	Expt. 1	Expt. 2	Expt. 3	Expt. 4
British Lion	93	92	—	—	62	94	—	—
Early Bird	82	86	—	—	68	68	—	—
Eclipse	88	—	—	90	92	—	—	36
Foremost	82	86	82	84	65	70	39	30
Wrinkled Seeded.								
Admiral Beatty ..	88	—	—	—	80	—	—	—
Onward	—	60	—	72	—	46	—	58
Progress	83	—	—	94	58	—	—	46
The Lincoln ..	72	—	—	78	47	—	—	70

Apart from cases where the emergence of untreated seeds was very high, considerable increases in emergence from the use of treated seeds were obtained with all the varieties tested. It is suggested that the variable results of different experiments may be related to differences in environmental conditions which were impossible to control.

Some evidence as to the influence of soil moisture during the period after seed sowing was obtained in the following manner. Untreated and treated peas of the variety Surprise were sown in boxes of fairly dry greenhouse soil. The boxes were divided into six groups. The first group was watered very heavily immediately after sowing, the others after increasing intervals of time as shown in Table III. An approximately equal volume of water was added to each box.

TABLE III.

Influence of Time of Watering on Pre-emergence Damping-off and its Control by Cuprous Oxide.

Time between sowing and watering. Hours.	Percentage Emergence.	
	Cuprous Oxide.	Untreated.
Expt. 1.		
0	12	0
18	70	2
42	56	8
64	73	15
88	71	33
112	72	56
Expt. 2.		
0	58	0
5	70	2
24	73	3
48	80	17
72	82	27
96	85	33

These data are in agreement with those of Horsfall (7) and L. K. Jones (11), who found that the shorter the interval between sowing and watering, the greater was the loss due to pre-emergence damping-off. The results suggest that the seeds are most susceptible to attack before germination or during its earliest stages, as even after the longest interval between sowing and watering, 112 hours, the plumule had not emerged. The protective effect of cuprous oxide is very clear from these experiments.

A number of authors have reported experiments in which organo-mercury seed dressings were used successfully to control pre-emergence damping-off of peas (4, 11). Experiments were therefore carried out to compare the relative efficiency of cuprous oxide and of organo-mercury seed dressings as seed protectants. These are summarised in Table IV.

TABLE IV.

PERCENTAGE EMERGENCE OF VARIOUS VARIETIES TREATED WITH CUPROUS OXIDE AND ORGANO-MERCURY SEED DRESSINGS.

Varieties.	Expt. No.	Treatments.					
		Cuprous Oxide.	Organo-mercury Dusts A	B	C	D	Untreated.
Round Seeded.							
British Lion ..	1	93	82	92	78	83	62
,, ,, ..	2	92	94	—	—	—	94
Early Bird ..	1	82	83	80	73	80	68
,, ,, ..	2	86	82	—	—	—	68
Eclipse	1	88	93	98	97	93	92
,, ...	2	90	58	—	—	—	36
,, ...	3	56	34	28	36	—	14
Foremost	1	82	75	67	87	66	65
,, ...	2	86	88	—	—	—	70
,, ...	3	82	78	87	64	—	39
Wrinkled Seeded.							
Admiral Beatty ..	1	88	92	93	88	92	80
Onward	1	60	56	—	—	—	46
,, ...	2	72	74	—	—	—	58
Progress	1	83	88	83	90	65	58
,, ...	2	94	86	—	—	—	46
The Lincoln ..	1	72	67	70	67	40	47
,, ,, ..	2	78	54	—	—	—	70

It will be seen that cuprous oxide compares favourably with the four proprietary organo-mercury dressings tested. All the dusts were applied to the seeds at the same rate, *i.e.* 0.25% by wt.

In Expt. 2, when the greenhouse temperature was unusually high, 70–80°F., the emergence of the varieties Eclipse and The Lincoln treated with organo-mercury A was low, the seeds of the latter variety especially being severely injured.

Field Trials.

The effect of the cuprous oxide seed dressing on pre-emergence damping-off was examined on a number of occasions under field conditions. Table V illustrates the influence of environmental conditions after sowing on the pre-emergence damping-off of two varieties, Surprise and Early Bird, and the protective effect of cuprous oxide.

TABLE V.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED SEEDS SOWN AT FORTNIGHTLY INTERVALS.

Date of Sowing.	Days before Maximum Emergence.	Var. Surprise.		Var. Early Bird.	
		Cuprous Oxide.	Untreated.	Cuprous Oxide.	Untreated.
25/2/37	38	32	8	61	23
11/3/37	26	65	26	67	31
25/3/37	15	82	58	73	63
8/4/37	12	76	72	70	66
22/4/37	12	82	72	76	73

At the time of the first two sowings the soil temperature was low and remained so until after the seedlings appeared, the average soil temperatures for the periods between sowing and emergence being respectively 38 and 42°F. At the time of these sowings also and for some time afterwards, the soil was very wet. The later sowings were made in gradually improving conditions for germination. In the case of these, the average soil temperatures between time of sowing and emergence were respectively 46, 52 and 53°F., and the soil became considerably drier.

In the case of the earlier sowings, made under very unfavourable germination conditions, pre-emergence damping-off was very marked and cuprous oxide was of value in producing distinct increases in the percentages of seedlings emerging. The results of the later sowings emphasise the point to which Brett and his co-workers (4) have drawn attention in their work with organo-mercury dusts, that under conditions favourable to germination the increase in stand from treated seed is negligible.

The results of other field trials are given in Table VI and confirm those discussed above.

TABLE VI.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED SEEDS IN AUTUMN AND SPRING SOWINGS OF SEVERAL VARIETIES OF PEAS.

Variety.	Locality.	Date of Sowing.	Treatments.		Emergence of Treated as % of Emergence of Untreated Seeds.
			Cuprous Oxide.	Untreated.	
Foremost ..	Worcester	30/3/37	79	77	102
Early Bird	Long Ashton	5/4/37	74	67	110
Eclipse ..	,,	11/11/37	64	48	133
Foremost ..	,,	,,	69	52	133
Eclipse ..	Worcester	7/2/38	68	40	170
Early Bird	,,	,,	89	80	111
Foremost ..	,,	,,	74	75	99
Forerunner	,,	,,	76	59	129

Except for the sowings made at the end of March and the beginning of April 1937 treatment of the seeds with cuprous oxide was usually beneficial.

Two trials were also made in the Evesham district in commercial plantings on the variety Foremost. In one, drilled 22/3/37, an increase of 30% was obtained from the use of treated seeds. In the second trial laid down on 4/4/37 the increase in emergence over the untreated seed was only 7%.

With regard to the relative protective values of cuprous oxide and organo-mercury seed dressings, the results of only one trial are available, other trials having been vitiated by the attacks of various pests. The trial reported here was carried out under commercial conditions near Bridgwater, Somerset. Untreated seeds, seeds treated with cuprous oxide and a proprietary organo-mercury seed dressing were sown on 24/12/37, the variety being Eclipse, and on 7/2/38, the variety being Foremost. After maximum emergence was attained, counts were made of the number of seedlings in yard lengths of row at approximate intervals of ten yards, sown by the same drill. The results are shown in Table VII.

TABLE VII.

Comparison of Stand of Pea Seeds Treated with Cuprous Oxide and Organo-Mercury Seed Dressings. Results Expressed as Percentages of Untreated.

Variety.	Date of Sowing.	Cuprous Oxide.	Organo-Mercury.
Eclipse	24/12/37	123	128
Foremost ..	7/2/38	128	119

The trial showed that the protection given by cuprous oxide was of the same order as that given by the organo-mercury dressing.

Possible Injurious Effects of Cuprous Oxide.

During 1938 two growers reported that seeds treated with cuprous oxide emerged more slowly than untreated seeds, and that subsequent growth was somewhat retarded. In one of these cases, with the variety Foremost, the condition occurred during the abnormally dry spring of that year, the seeds being planted in March. It will be remembered (p. 89) that in America also, cuprous oxide injury was found to occur in dry soils and under certain other conditions.

Experiments were carried out in the laboratory to determine whether the seeds might be injured or their rate of germination retarded by cuprous oxide treatment. Daily counts of treated and untreated seeds germinating on moist filter paper in petri dishes were made with a number of varieties, and the coefficient of velocity of germination was calculated in each case according to the formula devised by Kotowski (13). The results are given below in Table VIII.

TABLE VIII.

Effect of Cuprous Oxide on Germination of Pea Seeds in Petri Dishes.

Variety.	Cuprous Oxide.		Untreated.		
	Percentage Germination.	Coefficient of Velocity.	Percentage Germination.	Coefficient of Velocity.	Velocity of Treated as % of Untreated.
Admiral Beatty	68	17.9	98	20.6	86
British Lion ..	92	23.0	96	26.6	86
Early Bird ..	90	27.1	96	33.6	81
Eclipse ..	58	27.1	96	33.6	81
Foremost ..	86	25.9	98	30.4	85
Progress ..	82	21.7	84	21.8	99
Lincoln ..	86	19.8	96	25.0	79

It is evident that the rate of germination was retarded in every case except with the variety Progress. Marked injury occurred with treated seeds of the varieties Admiral Beatty and Eclipse.

The same seven varieties were sown in the greenhouse in wet soil. The emergence of treated seeds was somewhat slower than that of untreated seeds, but the final percentage emergence of treated seeds was lower only for the variety Eclipse.

The variety Eclipse, which was apparently the most susceptible to injury of those examined in this way, and the variety Surprise, one of the wrinkled sorts which, according to American authors, may be safely treated, were used in a further experiment. Treated and untreated seeds of these varieties were sown in boxes of sterile soil adjusted to three different water contents, 100%, 50% and 20% saturated. The soil water contents were maintained approximately at these concentrations throughout the experiment. Counts were made daily of the number of seedlings emerging, from which coefficients of the velocity of emergence were calculated. The results are summarised in Table IX.

TABLE IX.

Effect of Soil Water Content on Emergence of Treated and Untreated Seeds in Sterilised Soil.

Variety.	Soil Water Content.	Cuprous Oxide.		Untreated.		
		Percentage Emergence.	Coefficient of Velocity of Emergence.	Percentage Emergence	Coefficient of Velocity of Emergence	Velocity of Treated as % Untreated.
Eclipse ..	100% Saturated	96	9.6	96	9.6	101
	50% ,,	98	7.4	96	11.5	64
	20% ,,	46	6.8	92	7.9	86
Surprise	100% Saturated	88	10.6	80	10.7	99
	50% ,,	98	9.8	98	11.0	89
	20% ,,	72	7.8	92	10.1	77

Killing of the seeds occurred only in the dry, 20% saturated soil, the variety Eclipse being more severely affected, while the rate of emergence in both varieties was retarded in both 20% and 50% saturated soils. In the 100% saturated soil the dressing had no harmful effect whatever.

From the practical point of view these results indicate that, as found in America, there may be a possibility of injury to certain varieties when cuprous oxide treated seed is sown under dry conditions, such as prevailed from February to April 1938. It should be emphasised that these results are of a preliminary nature. It is hoped to investigate in detail the conditions under which cuprous oxide injury occurs, and also its mechanism.

Discussion.

The experiments which have been carried out indicate that pre-emergence damping-off of peas is likely to occur when the seeds are sown in wet and cold soils, a conclusion confirming the work of the majority of other investigators of this problem. It has been generally agreed by previous workers that round seeded varieties are more resistant to pre-emergence damping-off than wrinkled seeded sorts, but results recorded in this paper indicate that losses may be heavy in the field even with round seeded varieties.

It has been shown that when environmental conditions favour pre-emergence damping-off considerable increases in stand may be obtained by seed treatment with cuprous oxide. Greatest benefit

was derived from the treatment in autumn and early spring sowings. In comparison with organo-mercury seed dressings cuprous oxide gave equally good results. Some unpublished work by Baylis (3) carried out at the Imperial College of Science and Technology agrees with this result. No advantage was obtained from sowing treated peas in late spring or early summer under conditions favourable for germination, and it would appear inadvisable to do this since there is evidence that injury may occur under dry soil conditions. In this connection Baylis (3) found that both cuprous oxide and an organo-mercury seed dressing caused injury in the abnormally dry spring of 1938. In all the experiments reported in this paper injury by cuprous oxide occurred only in very dry soil whereas organo-mercury seed dressings occasionally caused injury in moist soil at moderately high greenhouse temperatures. Both types of seed dressing appear to have similar advantages and disadvantages, except that cuprous oxide is less poisonous, but further work needs to be done before a just conclusion can be drawn regarding their respective merits as seed protectants for peas.

Summary.

1. A review is given of previous literature dealing with pre-emergence damping-off of peas and its control by cuprous oxide.

2. Greenhouse and field experiments showed that an increased emergence of seedlings under certain environmental conditions may be obtained by treating the seeds with cuprous oxide.

3. Cuprous oxide compared favourably with organo-mercury seed dressings as a seed protectant for peas.

4. Evidence is presented that cuprous oxide may retard the rate of seedling emergence, and in dry soils may cause injury to certain varieties.

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A NOTE ON THE INCORPORATION OF GROWTH PROMOTING SUBSTANCES IN SEED DRESSINGS.

By H. E. CROXALL and L. OGILVIE.

Recent research in Canada has indicated that treatment of the seeds of certain crop plants, particularly cereals, with preparations of growth promoting substances (" plant hormones ") may result in more vigorous growth of the plants and in greater crop yields. An investigation is now in progress at Long Ashton Research Station on the effect of these substances incorporated in seed dressings. Up to the present this work, reported in detail elsewhere (1), has been carried out with several varieties of peas and one variety of dwarf bean.

The growth promoting substances employed have been naphthalene acetic acid, mixed naphthylidene acetic acids and indolyl butyric acid. These substances have been incorporated at concentrations from 1-20 parts per million by weight, in talc, cuprous oxide and a proprietary mercurial seed dressing.

The dressings are applied to the seeds by shaking them with 0.25% by weight of the dressings in the usual way till they are completely covered.

The following is a summary of experiments carried out to date with peas and dwarf beans :—

1. Seeds of each of the pea varieties, Admiral Beatty, British Lion, Early Bird, Eclipse, Foremost and The Lincoln, treated with the growth promoting dressings and others untreated or treated with a mercurial dressing alone, were sown in boxes of sterile soil. Plants from seed treated with the dressings containing growth promoting substances emerged more quickly than those from untreated seed or from seed treated with the mercurial dressing alone.

2. The plants resulting from seed treated with growth promoting substances grew more vigorously than the other plants. After three weeks the average dry weight of plants from such treated seed was up to 70% greater than that of plants from untreated

seed and up to 50% greater than that of plants from seed treated with the mercurial dressing alone. The varieties Admiral Beatty and The Lincoln responded most favourably to the hormone treatments. In a second experiment with The Lincoln, under different temperature conditions, increases of up to 42% in the weight of five-weeks-old plants were obtained by using dressings containing growth promoting substances.

3. When seeds were sown in soil heavily contaminated with damping-off fungi an increased emergence was obtained by using mercurial dressings containing growth promoting substances. The most striking results were obtained with wrinkled varieties such as The Lincoln. For example in one experiment with this variety the percentage emergences were as follows :—Untreated seed, 24% ; seed treated with the mercurial dressing, 52% ; seed treated with the mercurial dressing plus growth promoting substances, 70–82%.

4. Sowings of the varieties Foremost, Surprise and The Lincoln were made in the field during the month of May. Owing to favourable weather conditions at the time of sowing no marked differences were observed in the stands of plants of the varieties Foremost and Surprise resulting from the various seed treatments. The crop weights from seed treated with dressings containing growth promoting substances, however, were up to 20–30% greater then those from seeds treated with the same dressings without these substances, With the variety The Lincoln the stand was somewhat greater in the plots sown with seeds treated with growth promoting substances. The crop weights in this case were 20–30% greater in one trial, and 50–80% greater in a second trial in plots sown with seeds treated with growth promoting substances than in plots sown with seed treated with dressings not containing growth promoting substances.

5. There were marked differences in the responses of different varieties of peas to the dressings containing growth promoting substances. External conditions also influenced the reaction of each variety to these treatments. It was found that a dressing which caused stimulation under some conditions had a retarding effect on plants of the same variety grown under different conditions. No one dressing gave an optimum response on all varieties and under all conditions.

In the conditions under which these trials were carried out, however, dressings containing 5 parts per million of naphthalene acetic acid and mixed naphthylidene acetic acids respectively did not cause any damage and frequently had a very beneficial effect.

6. In one trial the effect of treating seeds of the dwarf bean variety Foremost with dressings containing growth promoting substances was to increase the rate of emergence and to promote more vigorous growth. In the case of the variety Early Prolific there was little response to the use of these dressings.

The effect of these dressings on seeds of other important crop plants is now under investigation by us.

Acknowledgment.

We are much indebted to the Horticultural Department, Messrs. Boots, Chemists, who supplied the mercurial seed dressings and growth promoting substances used in the experiments.

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A CALENDAR FOR FARM CIDER-MAKERS.

By VERNON L. S. CHARLEY.

In recent years the Cider Section at the Long Ashton Research Station has received a considerable number of enquiries from farm cider-makers in which information of a specific nature has been requested on a wide variety of questions dealing with normal processes concerned with the making of cider under farm conditions. Non-technical literature is not easily obtainable by farmers and, although the Research Station has from time to time issued leaflets on points of special interest, no complete presentation of the details of the various processes is readily available. It is hoped that this deficiency will be remedied in the near future, but the following notes have been compiled at this present time in view of the increased importance of achieving maximum efficiency in the farm cider-making industry under war-time conditions.

The notes are arranged in the form of a calendar which commences, for purposes of convenience of presentation, with the month of August. It must be emphasized that the various processes mentioned in a certain month may, and almost certainly will, extend into adjacent months, either before or after that mentioned in the calendar, and many points, such as "topping up," are of importance to a greater or lesser degree according to climatic conditions throughout the year.

No attempt has been made to give full processing details in the following notes. It is chiefly desired to draw the attention of farmers to certain important duties that must be carried out throughout the year in order to attain a satisfactory standard of quality and production.

August.

Examine all cider-making plant and arrange for necessary repairs and the sharpening of knives in grater type mills; remove rust from metallic surfaces which will contact fruit or juices and cover with vaseline or grease, or paint with special protective lacquers. Avoid use of solder in repairing pipes, interiors of filters, bottling machines, etc., and the use of lead in repairing cracks in stone mills. Examine filters with respect to the tinning, and arrange for re-tinning if necessary. Consider the question of

retaining natural sugar in cider and the possibility of procuring a suitable centrifuge to remove the yeast material. (See article on "The Retention of Sweetness in Cider," this Volume, p. 122).

September.

Prepare all cider-making plant for the season's work. Soak up trolleys and wooden racks; cooper casks and prepare sufficient number for early-made juice. Ensure efficiency of press and pumps by preliminary run. Make up early fruit and windfalls. Do not allow this fruit to lie on the ground until mid-season fruit is mature.

Calculate the proportion of the season's cider that can be allowed to ferment to dryness and what amount will need to be treated for retention of sweetness. This proportion should continually be born in mind when bulks of cider reach a specific gravity of 1.030–1.025.

October.

Consider the possibility of washing either all the fruit or only such bulks as show considerable admixture with dirt, leaves or grass. (A large tub filled with water in which the apples can be immersed and agitated can easily be adapted to afford an effective swilling of the fruit). Mill and press the fruit when it reaches maturity. If possible, make a determined effort to keep apples which are of the same degree of maturity in the same heaps. (This does not imply that single varieties should all be kept separate, but early fruit should be harvested and kept separate from mid-season or late maturing sorts). Do not pick up windfalls into sacks or even heaps and then add the mature fruit at a later date.

If casks have been stored since last season with a quantity of chemical preservative (calcium bisulphite), remove the liquor and rinse out casks with clean water before filling with fresh juice. Always smell every cask to test for moulds or "vinegary" taints before filling with juice. If persistent taint remains, attempt to remove it with steam, or by using a solution of 2 lbs. washing soda in 10 gallons of hot water. Thoroughly rinse casks before use.

Take specific gravity of fresh juice by hydrometer, and mark the gravity on each cask. Identify each cask of juice with the source of the fruit to enable the quality of the finished cider to be related to the district or orchard from which the fruit was obtained. Follow the fall in specific gravity at intervals, and mark on casks. By this means the rate of fermentation can be assessed and preparations made in advance for dealing with ciders which show very rapid fermentation.

As fermentation proceeds, wipe off residue from the white and brown "heads" and fit fermentation locks into the bungholes. In mild weather keep constant watch on specific gravities and treat medium sweet ciders by racking, centrifuging, filtering or any of these procedures in combination with SO_2. (See article on retention of sweetness in cider, this volume, p. 122.) Set aside special cask, preferably placed on its end, to receive lees from casks emptied by racking, etc. Allow mixed lees to settle and rack off top layer of cider.

Check excessively fermenting ciders by preliminary racking or centrifuging after about 10°–12° drop in gravity.

Bung down casks of racked, centrifuged or filtered ciders that have ceased active fermentation.

November.

As for October.

Continue with making operations and racking or other treatments for retention of sugar. For production of high-class ciders from mid-season fruit, attempt to obtain a rate of fermentation such that the specific gravity falls by approximately 1° each day.

Follow the procedure suggested for October by racking or centrifuging soon after the first fermentation has ceased.

December.

As for October and November.

Regulate milling and pressing operations to allow sufficient attention to be paid to the stabilising of earlier bulks of cider. Examine the first casks of cider to be made, especially those made from windfalls, and consider the necessity of further treatment to check secondary fermentation.

Wash and beat filter pulp immediately after removing it from filter. Do not allow pulp to dry out. Set aside a special vessel, such as a de-headed cask, and always keep pulp clean and free from contamination.

January.

Complete milling and pressing operations. Clean all machinery and apparatus. Pay special attention to the more inaccessible parts of the mill and press. Remove fruit residues, hose down apparatus and grease metal surfaces. Clean press cloths and wash. Cotton cloths may be washed in boiling water, but woollen cloths

must not be put into water above 160°F. A quart of calcium bisulphite added to the water helps to maintain cleanliness and sterility.

Continue processing to maintain sweetness in those bulks of cider needed for medium sweet trade.

Attempt to prevent rest of cider from fermenting completely to dryness. It is better to maintain a very slight fermentation over a long period to keep cider charged with gas rather than allow it to ferment down to a gravity of 1.000 and become " dead." A racking or centrifuging at a gravity of about 1.008 will usually achieve this object on ciders that would otherwise quickly become completely dry.

February.

Examine complete stock of cider. If possible, estimate acidity in the various blends. Attempt some form of blending with a view to adjusting the acidities of those ciders which show very low figures for acid content. Ciders with acidities below 0.4% should be blended with sharper ciders in this month, before any danger from *ropiness* or *cider sickness* is likely to arise. If suitable sharp cider is not available fruit acids, such as tartaric or citric acids, may be added to raise the acidity. A usual dose is 1 lb. per 100 gallons of cider (1 lb. of either of these acids added to 100 gallons of cider raises the acidity by 0.1%).

Completely fill up all casks of blended ciders and examine at intervals, increasing in frequency as the hot weather approaches.

Choose special blends for bottling purposes. If SO_2 has been used ensure that the quantity present is within the limits of the Food and Drugs Act.

Rack dry ciders from their lees. Collect lees and separate juice as for October.

Take stock of corks, wires, capsules, labels, bottles and stoppers, and order supplies for season.

Wash bottles. Insist on workmen " sighting " each bottle before stacking. If bottles have been rinsed regularly as they return from customers, this February washing process is made much easier and more effective. The temperature of the washing water is of the utmost importance and should never be lower than 140°F. At this temperature immersion for at least 20 minutes is needed for sterilization. Higher temperatures are advisable, and the use of a

detergent aids removal of yeast deposits or acetic films. Washing soda can be used for this purpose.

Have press cloths repaired.

March.

Examine casks and fill up where necessary with cider.

Towards the end of the month bottle up ciders which have fermented steadily but slowly under normal conditions of temperature during the main fermenting period.

To discover whether a cider is fit for bottling, it is advisable to test it beforehand by filling two bottles three-quarters full, corking them and putting them in a warm place, at 65°–75°F., for about a fortnight. If, after this test, only a small deposit is formed and the cider is sparkling when poured out it is an indication that the whole of the cider under examination may be bottled. On the other hand if a heavy deposit and an excess of gas are formed this indicates that it is too early to bottle, and a later test must be made until the result gives a reasonable condition with respect of deposit and gas.

Casks which are emptied in the normal process of trade should be thoroughly washed out and steamed if facilities are available. Empty casks should be treated with a small quantity of calcium bisulphite at the rate of 1 pint of bisulphite + 3 gallons water for a pipe (100–120 gallons), and the casks stored on end in some sheltered space. In very hot weather the heads should be covered with water which must be continually renewed.

April.

This is the chief month for bottling. Ciders that fermented at a quick rate should be bottled towards the end of the month and *vice-versa*.

At the end of the bottling season the filter pulp should be subjected to a thorough beating and washing, preferably in the simple mechanical machine specially made for the purpose, and stored in a cask or other vessel in the presence of sulphur dioxide. The usual quantity of calcium bisulphite used is a 50 : 50 mixture with water which is poured over the washed and drained pulp in sufficient quantity to saturate it.

No appreciable stock of sweet or medium sweet cider should be allowed to remain unblended or unacidified beyond this month if the acidity is less than 0.40%. The figure that is considered

safe as precaution against *ropiness*, *sickness* and to some extent *blackening*, is 0.5%, and low acid cider should have its acidity increased either by blending with sharp cider or by adding citric or tartaric acids.

May.

Maintain constant watch on ullage formation in casks and fill up where necessary.

Ciders which have been bottled and have shown signs of developing excessive condition and deposit can be pasteurized during this month. The bottles should be doubly wired, and laid horizontally on a false bottom in some vessel and covered with cold water. The temperature of the water should be raised to 150°F. in $\frac{1}{2}$-hour and maintained at that temperature for 20 minutes when the bottles can be removed and allowed to cool. For safety during pasteurization, in filling the bottles a space of at least 1 inch must be left between the cider and the bottom of the cork.

June and July.

Watch specific gravities and be prepared for downward tendency in gravities of sweet ciders if weather is hot. Filtration is a useful method of stabilising ciders at this period of the year when renewed fermentation is most likely to recur.

Clean empty casks and store away in the presence of calcium bisulphite as for March. Prevent drying out of the heads in hot weather by keeping moist with water.

THE RETENTION OF NATURAL SWEETNESS IN CIDER.

By VERNON L. S. CHARLEY.

One of the major effects of the War on the cider industry will be the difficulty in obtaining supplies of sugar, and stringent precautions will naturally be necessary to conserve the stocks of sugar apportioned to the industry. The process known as "checked fermentation," in which an appreciable percentage of the natural fruit sugar is retained in the cider, will obviously ease the sugar position and, in cases where juices with satisfactory original gravities are fermented and checked at a medium sweet gravity, this process will call for the use of only small amounts of sugar.

Various reports on the retention of sweetness have been published in the Annual Report of the Long Ashton Research Station (1, 2, 3, 4), but these have dealt chiefly with the use of the super-centrifuge and a comparison of its effectiveness with that of the filter. The commencement of War, however, in September 1939, brought a large number of enquiries requesting precise details of the most efficient way of dealing with the checked fermentation process. Short explanatory statements were broadcast and published in the daily press in October 1939 and leaflets were prepared for distribution. The following article is an expansion of the various leaflets, the fresh material being largely concerned with an explanation of general principles involved and allusions to the experiments carried out on this subject in the Cider-house programme in the winter of 1939. The results of this work are not yet complete, but it is hoped to give publicity to any new recommendations that may appear to be desirable before next cider-making season.

General Principles.

Active fermentation will take place in apple juice or cider when a supply of live yeast cells is accompanied by a sufficient quantity of the essential mineral or organic chemicals necessary for the nutrition of the yeasts. Provided the supplies of nutrients are adequate, a very few yeast cells can rapidly develop into enormous numbers and carry out a proportionately greater amount of fermentation. On the other hand, a very large number of live yeast cells will remain dormant in a medium which is "starved"

with respect to the essential nutrients for yeast development. These facts suggest that it is of paramount importance to remove yeast food from the juice if natural sugar is to be retained and this is the objective in all the processes mentioned later.

The writer has often been asked whether it would not be helpful to centrifuge or filter the freshly expressed juice and thus retard later fermentation. Such a treatment certainly postpones the onset of fermentation but, as the yeasts in fresh juice contain a very small proportion of the mineral foods, their removal by the centrifuge or filter does not appreciably reduce the "food level" in the juice. The comparatively few yeast cells remaining in the clarified juice gradually develop and propagate, and in due course the fermentation becomes as rapid as if no preliminary treatment had been undertaken.

The position is quite otherwise, however, in a medium sweet cider which is passed through the centrifuge or filter or even merely racked from its deposit. During the course of the fermentation the yeasts assimilate mineral materials, such as phosphates and organic compounds containing nitrogen, depriving the juice to an equivalent extent of these nutrients. The removal of the yeasts consequently results in the direct removal of a substantial proportion of nitrogenous and inorganic compounds, and the cider issuing from the centrifuge, filter or racking tube does not contain sufficient nutrients for the further development of the yeasts.

The above principles, interpreted into practical procedure, indicate that it is essential to allow the growth of a heavy crop of yeast material, and then to remove this yeast, together with its associated, assimilated nutrients from the cider. In actual practice, it has been found inadvisable to attempt the separation of the yeast until the cider has fermented 10—12° from the original gravity.

Methods of Fermentation Control.

(*a*) *Racking.*

This process is in wide use by farm cider-makers and in certain factories where adequate facilities exist for the convenient racking of large bulks of cider from one vessel to another. The process suffers by reason of the difficulty of achieving a thoroughly efficient separation of yeast material without leaving a considerable volume of lees which need separate treatment. When racking a cider which has fermented 10 –12° in gravity in a 100-gallon cask, it is necessary to place the racking tube about 4″ from the bottom of the cask, thus leaving a large volume of cider in the cask with the lees. Again, unless stringent precautions are taken to avoid access

of air to the juice, racking may actually increase the rate of fermentation. In experiments on large bulks of cider in the Long Ashton programme of research work in October—December 1939, the ordinary racking process was found to be an unsatisfactory means of retaining sweetness in large bulks of cider. Certain ciders responded admirably to the treatment but others were practically unaffected. If racking is to be entrusted with the duty of maintaining sweetness in a considerable bulk of cider, it should be combined with the use of a chemical preservative added after racking.

A quick series of rackings on an individual cider should be avoided. The efficacy of a racking treatment on a cider depends on the amount of yeast removed by the treatment and a suitable period must be allowed for an appreciable crop of yeasts to develop before effecting its removal.

Racking of a cider in full fermentation will usually have little effect as the yeast will be in suspension in the cider and not in the form of a heavy deposit. In France, racking is recommended to be carried out only on fine days of equable atmospheric conditions and pressure, which conditions conduce to the formation of a heavy deposit of yeasts.

(*b*) *Sulphur Dioxide* (SO_2).

This is the only preservative allowed by law for use with cider. The maximum permitted dose is 200 parts per million (p.p.m.), which is equivalent to 14 grains per gallon. The use of SO_2 is complicated by the following considerations :—

(*a*) It is oxidised by atmospheric oxygen to a compound which is not similarly toxic to yeasts.

(*b*) It combines with sugars and other compounds to form loosely combined chemical substances which have little or no toxic action.

With reference to (*a*), little can be done by the cider maker to minimise this loss, except to avoid undue aeration in processing, especially racking. With regard to (*b*), there are two important points which must be considered. The tendency of SO_2 to combine with sugars and similar compounds suggests that SO_2 should not be added to fresh juices, or juices and ciders which still retain considerable amounts of carbohydrates. Further, when active fermentation is taking place certain intermediate compounds, such as aldehydes, are presumed to have a momentary existence in the fermenting medium and these compounds, in the actual presence

of SO_2, can form quite stable products which involve the removal of a proportion of the SO_2 from active participation in yeast suppression. These two considerations indicate that SO_2 should not be added to fresh juices or to ciders in such a way or at such a period that active fermentation will ensue in the presence of the SO_2.

As a result of these conditions, it is clear that SO_2 will be most effective when it is added to a medium sweet cider (sp. gr. 1.035—1.025) in which the cider has been clarified and freed from the bulk of the yeast material by racking, centrifuging or filtering.

It is not possible to give any definite figure for the loss of SO_2 by oxidation or removal with the CO_2 evolved during fermentation, as this percentage loss varies with different varieties and with many other factors. The only accurate way is to determine the SO_2 content by the method given at the end of this article, and the amount in the cider may then be raised, if necessary, in accordance with the figures obtained. In the event of the analysis not being possible at the cider factory or farm, samples may be sent to Long Ashton for determination.

The maximum dose of SO_2 allowed by law in a cider offered for sale, *i.e.* 200 parts per million, is equivalent to $6\frac{1}{4}$ oz. potassium metabisulphite (K.M.S.) per 100 gallons of cider. The K.M.S. in powdered form is most convenient for general use. The SO_2 content of K.M.S. which has been in stock for some time should be carefully checked, and the solution of the powder should be effected with great care in a small volume of luke-warm water.

In general. it is advisable to restrict the use of SO_2 to the final stabilization of the cider at a gravity of 1.030—1.025. For perfect safety, centrifuged cider should be treated with the full dose of SO_2 (equivalent to $6\frac{1}{4}$ oz. potassium metabisulphite per 100 gallons). If the cider is to be stored for a period of months before consumption, there will probably be a 25% loss of total SO_2 in this period under normal conditions of storage in casks or wooden vats.

Fuller data from the 1939—'40 experiments are being obtained and will be reported on later.

(*c*) *Centrifugation.*

This method of retaining sweetness in cider has been discussed in full in various technical reports published by the Long Ashton Research Station. The centrifuge in its various forms has the following definite advantages :—

(i) It can be used effectively on thick, cloudy ciders of high specific gravity which show excessive rates of fermentation, where a filter would be practically useless. The actual period of the main fermentation can thus be lengthened, a very desirable result in the case of cooking and dessert apple juices or normal cider juices in periods of excessive warmth which causes turbulent fermentation.

(ii) It effectively removes the yeast cells and simultaneously clarifies the cider to a remarkable extent.

(iii) It results, in general, in a check to fermentation even more substantial than that caused by the filter.

(iv) It can deal with the entire bulk of cider to be treated, and reduces the lees to a hard, coherent paste of yeast and other materials. Where disposal of liquid lees constitutes a problem the centrifuge can generally provide a solution.

(v) It needs an absolute minimum of attention and repair, and runs for many hours without interruption.

The principles governing the most effective use of the centrifuge are similar to those for racking. The greater the growth of yeast prior to its removal in the centrifuge the greater will be the effect of the treatment in retarding fermentation. It is hardly ever worth while using the centrifuge before the cider has fallen 10—12 points in gravity and the best effect is found when the machine is used at this gravity and again at about 1.030. In many cases of normal rates of fermentation it is not necessary to centrifuge at all until the cider reaches a gravity of 1.030 ; treatment at this gravity will often check the fermentation to such an extent that the cider becomes " dead." In cases where excessive rates of fermentation are expected the double treatment, with or without a threequarter or full dose of SO_2 after the initial centrifuging, should be adopted.

The drawbacks to the use of the centrifuge by farm cider-makers in the past have been the expensive nature of the machine and the large output of the standard commercial types. During the recent cider-making season, extensive and remarkably efficient use has been made of a small Alfa-Laval centrifuge with an output of 15—30 gallons per hour. Practically clear ciders were obtained and the machine should prove an attractive investment for small makers. The whole question of small scale centrifugation is being actively pursued and the possibility of using other forms of apparatus

(*e.g.* milk centrifuges) is being examined, especially with regard to the centrifugal power of the machine and the metals used for the parts coming into contact with the juice or cider.

Both factory and farm cider-makers who use the centrifuge method should take adequate precautions against the incidence of acetification in centrifuged ciders. The absence of active evolution of gas may allow the development of acetic bacteria and low-acid, centrifuged ciders are likely to be attacked by sickness bacteria when the warm weather commences. A careful blending programme should be arranged to obviate this latter danger.

(*d*) *Filtration.*

The filter was the first machine introduced for the purpose of retaining sugar in cider and it is in wide use amongst farmers and small makers of cider. Filtration suffers from the disadvantage of being a time-consuming process, occupying much time over the packing and unpacking with pulp and the associated process of washing and beating of the filter pulp. These manipulative inconveniences assume greater importance when it is desired to make use of the filter when the active making season is still in progress and, in circumstances like these, the advantages are all on the side of the centrifuge. However, from the point of view of brilliance, the filter gives a perfect clarity which is definitely superior to that imparted by the centrifuge and for this reason alone the filter is still to be regarded as an essential piece of cider-house equipment.

It is generally impossible to use the filter for ciders with gravities greatly in excess of 1.035 and consequently the filter finds its chief use in effecting the final stabilization of the medium sweet cider rather than in being applied to any process of lengthening the fermentation of quickly fermenting ciders. With this one difference in mind, the use of the filter is similar to that of the centrifuge and the same principles are involved in each case.

General Precautions.

All vessels used for the reception of racked, filtered, or centrifuged ciders should be steamed or otherwise rendered as sterile as possible. Regular inspection of the gravity of the cider and the ullage in the casks should be made, and the necessary action taken either to check the fermentation once again or to fill up the casks to full capacity. The specific gravity hydrometer should be in constant use throughout the making season and until the cider is stabilized.

Determination of SO_2 in Cider.

The recognized method for determining the SO_2 in cider is that of Monier-Williams, but special apparatus is needed and an individual determination takes about two hours. An alternative method is available, however, which affords reliable results of sufficient accuracy for the present purpose.

Apparatus needed.

Small conical glass flasks (200—300 cc.).
3 graduated pipettes (50, 25, 10 cc).
1 „ burette (25 or 50 cc).

Solutions needed.

$\frac{N}{50}$ iodine.
5.6% KOH.
Sulphuric Acid (1 + 3).
Starch solution (soluble starch dissolved in hot water).

Method.

Measure 50 cc. cider into a conical flask and add 25 cc. KOH solution. Stopper the flask and agitate it at intervals for 15 minutes. Add 10 cc. sulphuric acid (1 + 3), a few drops starch indicator and titrate with $\frac{N}{50}$ iodine from burette. The endpoint is taken when the blue colour persists for a period of ten seconds. The titration in ccs. multiplied by 0.896 will give the SO_2 content in grains per gallon (maximum allowed by law = 14 grains per gallon = 200 p.p.m.).

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CONCENTRATED FRUIT JUICE PRODUCTS WITH SPECIAL REFERENCE TO THE APPLE.

By VERNON L. S. CHARLEY.

The concentration of fruit juices has received much attention in recent years and the enormous surplus apple crop which was available for harvesting in the Autumn of 1939 focussed attention on this method of conserving fruit that would otherwise be wasted. The special war-time need of utilising every source of foodstuff that possesses a definite food value suggests that the production of concentrated juice products from English-grown soft and tree fruits should be given serious consideration both in the event of further glut crops during the war and in cases where fruit may be otherwise used in such a way that its nutritive value is depreciated to some extent.

Although much technical information concerning chemical and engineering aspects of fruit juice concentration has been collected during various recent investigations at Long Ashton, it is not intended to refer in detail to these data in this communication. It is desired rather to discuss in broad outline the problems involved in this method of conserving fruit material and to offer suggestions regarding the possibility of organising a scheme whereby wastage of fruit could be prevented by such means.

Methods of Concentration (1, 2, 3, 4, 5, 6).

Two main groups of methods are available for concentrating fruit juices, *i.e.* the hot treatment of evaporation in vacuo and the cold method of freezing the juice and centrifuging the concentrate away from the ice. Undoubtedly the hot process is in chief use throughout the world and, although the freezing method affords concentrates with much fresher flavours, the technical difficulties, capital, plant and running costs are of such a nature that the cold process can hardly be considered as having yet reached the same stage of mature development as the more recently introduced methods of vacuum evaporation. The freezing process of Dr. Krause, of Munich, has been adopted in one or two factories in Germany, but it is doubtful whether the processing is entirely

carried out by the cold method on account of the difficulty of obtaining economic yields of concentrate of a high sugar content.

Vacuum evaporation is widely employed as a means of removing water from fruit juices until the natural sugar content is raised to a figure sufficiently high to enable the concentrates to be preserved from fermentation. The degree of concentration varies from 1:5 for apple and black currant juice to 1:10 for other fruit juices such as strawberry and raspberry. Two types of vacuum concentrators are used for fruit juices. The first type consists merely of a vacuum pan, in which the juice is heated by a Calandria System under a vacuum of about 27″—28″. The process is not continuous and the whole bulk of fruit juices is continuously exposed to the increasingly higher temperature necessary to boil the concentrated product. There is also a tendency to lose flavouring compounds when this method is used, although this deterioration is not found to be as serious as might be expected except in the case of a very delicately flavoured juice such as that from strawberries.

The alternative type is known as the Climbing Film Evaporator, which has the advantage of being continuous in operation and of being capable of an adaptation which allows of the continuous collection of the aromatic compounds and their return later to the concentrate. The period of time during which the juice is exposed to the heating surfaces is extremely short (probably not longer than 2 minutes), whereas in the batch process machines the juice may be held at an elevated temperature for periods up to 6 hours. A further advantage of the Climbing Film Evaporator is associated with the phenomenon of film formation which occurs immediately the juice under vacuum enters the steam-heated jacket. The significance of this lies in the fact that the full extent of the vacuum is exerted throughout the whole depth of the various heating " effects," thus holding the temperature at as low a level as possible.

Long Ashton Investigations.

During the War of 1914—18 a scheme for the concentration of apple juice and its conversion into a form of jelly was devised and carried out under the direction of Professor B. T. P. Barker. Full details were published in the Annual Report for 1917, but as this is now out of print the chief points of interest in the present war emergency will be given in very brief form.

The work was initiated by the Food Production Department of the Board of Agriculture with the purpose of utilising a portion of the abnormally large cider fruit crop of 1917. Two centres of production were established, at Long Ashton and Wedmore in

Somerset. The plant at Long Ashton consisted of a grater mill and a hydraulic press, but the Wedmore centre could only be equipped in the short time available with a crusher mill and two small hand power presses.

The evaporators, although they would be considered most unsatisfactory to-day, were of fairly common design in 1917. The Wedmore machine was similar in design to American juice evaporators. The juice was led along a devious route within a wooden compartment and steam heat was applied to evaporate the water. The plant was difficult to regulate and uniformity of product was very difficult to achieve. The Long Ashton machine was a Kestner evaporator of the ascending film type but operated at atmospheric pressure on account of the inability to acquire a suitable vacuum pump in time for the season's work. The plant was much easier to regulate than that at Wedmore.

Certain general directions were given by Barker as a result of the season's work. The points which should be emphasised are as follows :—

Type of Fruit.

The fruit should consist of sweet or bittersweet varieties. Sharp apples should only be blended to the extent of $\frac{1}{3}$rd of the total quantity, and not more than $\frac{1}{6}$th if added sugar is not to be used for the jelly making. The malic acid content in the jelly should lie between 1.0—1.5%.

Condition of the Fruit.

Fruit should always be milled as near to normal ripeness as possible. It is better for the fruit to be slightly overripe than underripe from the point of view of the setting of the jelly.

Supplies of Juice.

Juice should never be prepared in excess of the requirements of the evaporator for 24 hours ahead on account of the possibility of fermentation. At Long Ashton two blending vats, each of 750 gallons, were used for a 15-hour working day for the evaporator.

Standardisation of Acidity of Juice.

The acidity of the supply of juice is brought to the standard composition by blending. This standard will depend on the degree of concentration necessary, *i.e.* according as to whether sugar is to be added or not. The most effective way of working

is to raise the sugar content of the juice to 20% by adding cane sugar or corn syrup or a mixture of both, in which case the standard of acidity is taken as about 0.35% and the concentration is carried to about $\frac{2}{7}$ths of the original volume.

Use of Sugar.

Where sugar is available at an appropriate price its use is desirable for reasons concerned with the economics of the plant operations and the standardisation of the product. Cane sugar addition generally gives a sweeter, firmer jelly, whilst corn syrup (glucose, maltose, dextrin) yields a less sweet article of a more treacly consistency. A mixture of the two sugars is preferable. The addition of sugar reduces the total flavour and is useful in the case of ultimate products which would otherwise possess an excessive astringency or acidity. In 1917 it was preferred to add the sugar to the juice before concentration.

Use of Pectin Extract.

The variability of the juices in pectin content made it necessary to add a small quantity of pectin extract to the juice before evaporation. The extract was made by passing waste steam from the evaporator into a mass of pressed apple pomace and expressing the liquor. This thick liquid was added to the juice at a rate of 15% by volume of the juice. With the extract an additional quantity of sugar was used (15 lbs. sugar per 15 gallons extract) to avoid a too low sugar concentration.

Clearing the Juice.

The juice was merely strained through calico and the remaining turbidity almost completely disappeared in the later stage of concentration. It appeared that the sudden clarification of the concentrate could be taken as a safe indication that the " jellying " stage had been reached. No completely brilliant jelly, however, was obtained by this process.

Concentration of Juice.

The concentration was taken to such a stage that the jelly contained 60—65% sugar. The Kestner plant could be easily controlled to give this concentration but the Wedmore machine was very variable in operation.

Receptacles.

Two types of containers, glazed earthenware pots and waxed papier maché pots were used. In the latter case the concentrate

was cooled to 65°C or lower to avoid melting the wax-lining. The jelly kept quite satisfactorily in both containers, but exhibited a slight tendency to be hygroscopic in damp atmospheres.

Output.

The Kestner plant at Long Ashton dealt with 100 gallons juice per hour, giving 275 lbs. jelly in that period.

The Wedmore plant only dealt with 30 or 40 gallons per hour, and for this reason is not considered in the costs section below.

The total approximate output of jelly for the 1917 season (Nov.—Dec.) was :—

Long Ashton	156,000 lbs.
Wedmore	56,000 lbs.

produced from a total weight of 460 tons of apples.

Costs.

At the time of writing the Report complete costings had not been made, but a table containing practically all the necessary figures was given :—

Particulars of Cost of Material and Wages for making 156,246 *lbs. of Jelly.*

Juice and Pomace Extract	£1,416 13 3
Sugar and Corn Syrup	1,299 18 4
Pots	658 0 2
Wages	188 8 2
Coal	138 14 3
Jam Covers, etc.	82 16 10
	£3,784 11 0

This figure equals 5.81d. per lb.

These abstracts from the 1917 Report have a special significance at the present time as they represent the results of a commercial venture which was the direct outcome of the occurrence of an abnormally heavy crop simultaneously with difficult food conditions due to the War.

The next reference to concentration in the work at Long Ashton was a report by Grove (1), which, although it presented no actual experimental data, referred to a new type of product called " apple treacle," capable of being made from very sharp apples such as

Bramley's Seedling. The original feature of the process for treacle was the removal of the pectin in the fresh juice to prevent the formation of a gel in the concentrate. The pectin was removed by allowing the juice to ferment for a few days and the acidity of the juices was reduced to 0.1—0.12% by suitable chemical neutralising agents. Concentration was taken to 65% sugar content, and it was found preferable to add 5% cane sugar and 5% liquid glucose for economical and other reasons before concentration.

Recent Long Ashton Investigations—1935-40.

The present writer commenced an investigation into fruit juice concentration in 1935 and first used a vacuum pan of 100 gallons capacity for the batch processing of fresh juices. The concentration of cider apple juices presented no difficulties, but culinary juices gave rise to many technical problems, the chief of which concerned the necessity of removing part of the pectin in the juice to avoid the concentrate becoming a thickly viscous material or even a solid jelly. The flavours of apple juice concentrates were noticeable for their " cooked " character, this being most prominent in the bitter and high acid juices. The concentrates from soft fruits were not considered to be satisfactory—the delicate fresh flavour disappeared and in the case of black currant a flavour quite different from that of the fruit was imparted to the juice.

In 1936 it was found possible to make experimental use of a Triple Circulation Vacuum Evaporator of the Kestner Climbing Film type in a Bristol factory. The evaporator was used for strawberry, raspberry, black currant and apple juices, and its use indicated that the process was capable of obviating some of the disadvantages of the batch process. Very clean, fresh flavours were obtained, and the concentrates of 60% sugar content have remained free from fermentation from that year until December 1939. The pilot plant used in the tests was capable of concentrating 8 gallons of fresh juice per hour and was fitted with a special device for collecting the aromatic compounds. The plant was an exact replica of large size machines capable of dealing with 600 gallons of juice per hour. The design and full details of the tests have already been published elsewhere (6)

The experiments showed that concentrates could be made from soft fruits and apples with satisfactory retention of fruit character and freedom from fermentation.

In September 1939, immediately after the commencement of the War, the writer arranged for the same plant to be used in London for the production of limited quantities of apple juice concentrates,

" treacle " and jelly. The " treacle " material was a very highly concentrated de-pectinised juice, whilst the jelly was virtually the " treacle " product to which some apple pectin had been added previous to concentration. In view of the urgency of the tests any fruit which was available was used and consequently Morgan Sweets, Dabinetts and mixed windfall apples of all varieties were converted into juice for concentration. These experiments indicated that most attractive products of liquid and solid consistency were produced from fruit of mediocre quality. A continuation of these preliminary experiments was made possible by the erection of the Kestner plant at Long Ashton in November 1939, and an examination of the technical problems was commenced. Some of the salient features of more immediate application will be alluded to here, although the full report on the experiments will not be published until they are completed.

Pectin Content of Juices and Concentrates.

The pectin content of freshly expressed juices varies very considerably. Previous studies by the writer have indicated that the calcium pectate content of cider juices varies from 0.022—0.178%, whilst generally high figures are found for culinary juices. The highest pectin contents are associated with juices from ripe or slightly overripe fruit of cooking sorts.

It was found almost impossible to concentrate cooking or dessert apple juices to $\frac{1}{7}$th their original volume without the product solidifying in the reception vessels after the third heating " effect " on the plant. The degree to which the jelly was actually formed in the heating tubes varied to a remarkable extent, and no information other than a calcium pectate value was available to show whether a juice would set into a jelly or remain as a treacle product on concentration, and this value proved by no means a sure indication of the later behaviour of the juice.

Pectin Removal.

The precise aim of the investigations in September and October 1939 was to determine the practicability of evolving large scale commercial production of concentrated products from the fruit which was then becoming surplus. For this reason it was considered quite impossible to arrange for differential treatment based on analyses for calcium pectate and consequently it was decided in all cases to standardise the pectin content by removing the pectin by enzyme action. 1 lb. enzyme was capable of altering the pectin constituents in 100 gallons of juice sufficiently to enable the juice to be concentrated to specific gravities up to 1.400 without any gel

formation. The enzyme normally needs a period of 12 hours for its action and the cost amounts to about ½d. per gallon of treated juice.

Clarification of Juices.

The need for clear products indicates that the juices should be filtered previous to concentration. The use of enzymes to remove pectin compounds has a remarkable effect on the life of a filter pack when it is used for clarifying fresh apple juice. If a centrifuge is used as a pre-filter, even larger quantities of juice can be passed through a filter of the pulp or plate and frame type. If enzymes are not used, filtration of fresh juice becomes a very difficult matter.

Collection and Return of Volatile Constituents.

The volatile fraction from the juice was obtained by using the patented Kestner method which is continuous. It was found by Dr. A. Pollard, the biochemist associated with these investigations, that it was preferable to take off volatile fractions of approximately 5% calculated on the volume of feed. This water solution or suspension can be concentrated to such a small bulk that its return to the concentrated product does not appreciably reduce the specific gravity. The volatile fractions from fresh and sound apple juices are notable for very characteristic apple aromas which, however, are apt to be very considerably masked by a slightly unpleasant aroma whenever alcohol produced by fermentation in the juice is present to any extent. Certain bulks of fruit were specially chosen to be free from spoilation and the ester fractions could be definitely associated with the fruit in question. Very delightfully smelling liquors were produced from Allington Pippins, but the finest sample was obtained from some second-grade Cox's Orange Pippins which had been frozen in the cold spell for several weeks and consequently were not milled until the middle of February 1940. The true, unique Cox character was readily noticeable in the volatile fractions taken off in the Kestner plant.

The aqueous liquor containing the aromatic compounds is liable to deteriorate very quickly and the flavour is further destroyed by mould action. Consequently it is essential to return the volatile constituents to the concentrate as soon as is possible.

The return of the volatile fractions to the concentrate has a marked effect on the finished product when it is diluted back to its original strength. The effect is not quite so noticeable when products such as treacle or jelly are tasted in the concentrated condition.

Suggested Procedure for Blending.

The many difficulties which are associated with achieving a blended and standardised product are practically insuperable when finished products are being made each day from the previous day's input of mixed apples. The character of the ultimate treacle or jelly will vary from day to day. Consequently it is suggested that it would be preferable to concentrate all the juice available to a strength of about 70% total solids and store in suitable vessels. De-pectinised juices will retain satisfactory fluidity at that concentration at ordinary temperatures and the composition of the various bulks can be ascertained and an exact standardisation achieved by calculation and blending.

The concentrated material can be used when needed for any of several purposes, of which three can be enumerated here :—

(*a*) Sweetening of cider or other products.

(*b*) Dilution with water to original strength for fermentation into cider or stabilisation as apple juice.

(*c*) Conversion into jelly by warming to 140°F. with pectin extract.

The jellies made at Long Ashton in the winter of 1939 were usually made by the admixture of 10% of a commercial pasteurised, concentrated pectin extract of light brown colour with the concentrate, warming to 140°F. and then filling into jars. The low acidity conditions mentioned by Grove were never fulfilled ; in all cases much higher acidities were allowed to remain in an endeavour to avoid chemical adjustment of the juices. Acidities in the jellies up to 3.0% do not appear to affect adversely the " set " of the product, but acidities in excess of 2.5% do not commend themselves to the majority of consumers.

With regard to treacle, one phenomenon deserves mention. It has recently been noticed that the viscosity of apple treacle is apt in some cases to decrease on long standing. It appears to be an acidity effect and is being investigated. The very thick nature of a satisfactory apple treacle suggests that direct filling from the evaporator is advisable rather than attempting to store the fully evaporated material in bulk. An alternative method, which has not yet been examined, would involve the addition of liquid glucose to the stored, concentrated juice of a gravity of 1.350 until the consistency is satisfactory.

Added Sugar.

The question as to whether sugar should be added in the processing of treacle or jelly largely depends on the relative cost of

the sugar material as compared with the cost of the concentrate, the latter being calculated on its sugar content.

Before the war a considerable saving in cost would have resulted by blending equal volumes of concentrated apple juice and invert sugar or liquid glucose of suitable density, but under war conditions undoubtedly the greatest appeal that will be associated with the products is the fact that they can be made entirely without added sugar. The position regarding supplies of sugars, other than cane and beet sugars, is not known at the time of writing this report. A possible cheapening of the final product may result from the use of invert sugar, even at war-time prices, and its inclusion in the scheme for processing would certainly help with the blending of very sharp or very bitter concentrates for which suitable supplies of low acid or tannin products are not available.

Outlines of Commercial Processing Scheme for 1939 Apple Crop.

The autumn of 1939 brought one of the largest crops both of market and cider apples in living memory. It became obvious during October that there was going to be an enormous surplus of apples and that drastic action would be needed to avoid waste. The canners packed every possible container with apple products and the apple juice and cider manufacturers filled all available vessels with unfermented or fermented juice. Yet despite all these extra outlets it was clear that fruit was already wasting even at that period of the year with the prospects of even worse losses later on. In view of the experience of 1917, the writer suggested that concentrated juices should be prepared and stored in barrels or other vessels and made up at a later period into some form of domestic product. The chief difficulty was associated with the concentration plant, which could not be made under 4 months from date of order. Contact was made with a Somerset firm who expressed their readiness to place their large Kestner vacuum evaporator with an input of juice of 10,000 gallons per 20-hour day at the disposal of the authorities for the production of apple treacle and jelly products —provided a large enough output was maintained and that some guarantee could be given with regard to sales. After some negotiations no Government or other official body felt able to take an active and financial interest in the project and the scheme was not adopted, with a subsequent considerable wastage of apples. During the discussions, the writer was responsible for drafting a scheme which would be workable at short notice and some of the details are given here in the hope that they may possibly be of use should such a situation arise again during the course of the war or later.

The evaporator was situated at Frome in East Somerset, about 25 miles from Bristol. The first problem was the supply of raw juice at the rate of 10,000 gallons per day for a 7-day week and extending for a period of about 8—10 weeks. It was arranged that cider or other factories with pressing equipment should press out and filter an enzymed juice at the rate of 65,000 gallons a week. This output was the maximum that could be arranged in the county of Somerset, and it was thought to be inadvisable to proceed further afield on account of transport costs. Transport would have been by means of stainless steel road tanks of 3,000 gallon capacity, the charge between Bristol and Frome being 0.2d. per gallon of juice.

It was decided that the concentrated juice should be stored in suitable receptacles and made into jelly or treacle later on, or else sold in the liquid form for sweetening purposes. (Incidentally, there has been a great demand for concentrated juice for this purpose since the war and the supplies are insufficient to meet the demand.) In view of the very large scale of suggested production imposed on the writer by the firm concerned, it was considered impracticable to extract the pectin from the pomace and consequently it was intended to purchase English liquid apple pectin to set the jelly.

It is obviously difficult to give any accurate information regarding costings for the product, as these will vary very considerably according to the facilities already available for expression and concentration of the juice. Certain figures, however, have been calculated during the course of recent months, and information on this subject can be obtained on application to the Fruit Products Section at the Research Station.

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THE PRESERVATION OF VITAMIN C IN ENGLISH FRUIT JUICES AND SYRUPS.

1. THE EFFECT OF PRESERVATIVES, PASTEURISATION AND SUGAR CONCENTRATION ON THE INDOPHENOL REDUCING CAPACITY OF STRAWBERRY AND BLACK CURRANT JUICES AND SYRUPS.

By V. E. SILLS.

Introduction.

Until recently much of the experimental work in connection with the preservation of Vitamin C in fruit juices has been confined to those of the citrus type. It has been shown by Bennett and Tarbert (1) that unpreserved lemon and orange juices can be kept for long periods without appreciable loss in their reducing power, but that this is not the case when preservatives are added. Furthermore it was observed that the destructive effect of sulphur dioxide was more marked in lemon juice than in orange juice. Similarly, Williams and Corran (2) have reported that at laboratory temperatures lemon juice preserved with 0.02% sulphur dioxide for approximately one month had lost at least 50% of its antiscorbutic potency. On the other hand, Morgan *et al* (3) and Joslyn and Marsh (4) have indicated that sodium benzoate is without effect on the Vitamin C potency of orange juice. In an attempt to explain the gradual loss of ascorbic acid in preserved and unpreserved orange juices Joslyn and Marsh stress the importance of the presence of dissolved air, and size of head space in the container. These investigators demonstrated that pasteurisation and sodium benzoate were practically without effect on the Vitamin C potency of orange juice if oxygen was excluded.

Another aspect on the question of the stability of ascorbic acid in plant juices is dealt with in a paper by Damodaran and Nair (5). Attention is drawn to the fact that the ascorbic acid present in the juice of the fruit of the Indian Gooseberry (*Phyllanthus emblica*) is extremely resistant to atmospheric oxidation; even when the

fruits are dried a considerable proportion of ascorbic acid remains unaffected. The existence of a protective mechanism constituted of tannin complexes was demonstrated. Such a system might well account for the comparative stability of ascorbic acid in black-currant juice, the latter having a relatively high proportion of "tannin." There is, however, no direct evidence as yet in support of this conjecture.

The utilisation of the chemical method of Tillmans *et al.* for the estimation of antiscorbutic potency in plant juices is amply justified in view of the work of Birch, Harris and Ray (6) and many others. Conclusive evidence is presented to indicate the correlation between the amount of ascorbic acid existing in a variety of food materials, and the antiscorbutic value as determined by biological assay. Results are generally expressed as ml. of $\frac{N}{1000}$ indophenol rather than mg. of ascorbic acid since the titration with indophenol may result in the inclusion of a small amount of oxidising substances other than ascorbic acid.

During the recent investigations on commercial pure fruit syrups at Long Ashton, it has been felt that there was need for new knowledge of the factors controlling the stability of Vitamin C in preserved fruit juices and syrups. The work has been complicated on account of the fact that sulphur dioxide, which is of considerable value to the fruit juice industry as a preservative, causes interference with the indophenol method of estimating ascorbic acid. A method had therefore to be found, and one is described later in this paper, for the estimation of ascorbic acid in juices and syrups containing sulphur dioxide.

The experimental work underlying this report has been undertaken with the object of discovering how the various methods of preservation applied to fruit juices and syrups influence antiscorbutic potency during long-term storage. The results are given in the experimental part.

Experimental.

Methods of Analysis.

(*a*) *Determination of Ascorbic Acid in Absence of Sulphur Dioxide.*

Ascorbic acid was estimated according to the procedure of Harris and Ray (7) using Tillmans' indicator, 2 : 6 dichlorophenol indophenol. The dye solution was standardised regularly against

$\frac{N}{1000}$ ferrous ammonium sulphate and occasionally checked with pure ascorbic acid. Fresh solutions of dye were made up each week. 1 ml., or smaller, samples of juice and syrup were acidified with a few drops of 8% acetic acid prior to titration with indophenol.

(*b*) *Determination of Ascorbic Acid in Presence of Sulphur Dioxide.*

Sulphur dioxide itself reacts with indophenol and therefore its elimination is essential. Bennett and Tarbert estimated ascorbic acid by indophenol titration in citrus juices which had been previously treated with sulphur dioxide by first removing the latter by distillation in a current of carbon dioxide. They gave few details of their method, but the following procedure has given good results in this laboratory :—

50 ml. of juice or syrup are acidified with sufficient citric acid solution to raise the total concentration of acid to 10% approximately, on dilution to 100 ml. 50 ml. of the latter solution are then transferred to a 100 ml. round-bottomed flask, through which a stream of carbon dioxide is passed, and heated to boiling. Gentle ebullition is maintained for 15 minutes after which the whole system is immediately cooled under an atmosphere of carbon dioxide by immersion in cold water. The solution, now free from suphur dioxide, is made up to volume and a portion titrated with indophenol as described under (*a*).

The accuracy of this method was tested by applying it to samples of freshly prepared strawberry syrups containing 350 p.p.m. of of sulphur dioxide to which known amounts of pure ascorbic acid had been added. An average recovery of 97—98% of the theoretical values was effected under the stated conditions. A typical example of an analysis is given below :—

	Material.	*Titration* (ml. dye required per ml. solution).	
(i)	50 g. strawberry syrup containing 350 p.p.m. SO_2, made up to 100 ml. and distilled, etc.	0.41 ml.	difference due to added ascorbic acid = 2.02 ml.
(ii)	50 g. strawberry syrup containing 350 p.p.m. SO_2, + 0.05g. l-ascorbic acid made up to 100 ml. and distilled, etc.	2.43 ml.	
(iii)	0.05 g. l-ascorbic acid dissolved in 100 ml. distilled water	2.08 ml.	

Recovery of added ascorbic acid $= \frac{2.02 \times 100}{2.08} = 97.2\%$

It has been noticed, however, that if sulphur dioxide is added to a juice containing " reversibly oxidised " ascorbic acid, the indophenol equivalent may actually exceed the value obtained by direct titration before addition of sulphur dioxide. The explanation apparently lies in the ability of the sulphur dioxide to " reduce " a proportion of the reversibly oxidised ascorbic acid to a form titratable by indophenol. Since there is no evidence in the literature to show that reversibly oxidised ascorbic acid exists in the plant such an anomaly should not arise in a freshly prepared juice.

Preparation of Materials.

Strawberry.

30 lb. of good quality Royal Sovereign strawberries were reduced to a pulp and immediately pressed through cloth. The expressed juice was filtered through muslin and divided into three portions for subsequent treatment. One portion was divided into 6 parts and treated according to the following scheme :—

(i) Untreated.

(ii) 350 p.p.m. of sulphur dioxide added (in the form of potassium metabisulphite).

(iii) 600 p.p.m. of benzoic acid added.

(iv) Pasteurised at 160°F. for 30 minutes in closed miniature bottles.

(v) pH adjusted to 2.3 by addition of concentrated HCl.

(vi) Acidity raised to 2.5% by addition of citric acid.

Another portion of the fresh juice was made into a syrup of 50° Brix strength by addition of solid cane sugar, divided into 4 parts and treated as (i—iv) above.

A third portion was made into a heavy syrup of 65° Brix strength by addition of solid cane sugar. This was bottled without further treatment.

The above lots of juices and syrups were filled into a series of miniature bottles of 60 ml. capacity and corked, leaving a small head space.

Analysis of fresh strawberry juice gave :—

Total Acidity	0.91% (as citric).
pH	3.68
Ascorbic acid	48.0 mg./100 ml. (calculated from 5.46 ml. N/1000 dye per ml.).

Black Currant.

Owing to the difficulty experienced in obtaining fresh juice from black currants and the tendency of the juice to set to a stiff gel within a very short time of expression, it was necessary to treat the freshly pulped fruit with a pectin-decomposing enzyme to facilitate removal of juice.

About 40 lb. of ripe black currants of mixed variety were milled and allowed to stand in bulk for 48 hours in presence of 0.2% Filtragol. Unfortunately a slight fermentation developed during maceration but this was not considered sufficient to prejudice the value of the experiment to any appreciable extent. At the end of this period the juice was easily expressed.

A series of juices and syrups similar to those for the strawberry experiment were prepared and bottled as described under (a) above, except that the juice did not require acidification with citric acid as indicated in series (vi) and this treatment was consequently omitted.

No attempt was made in these series of experiments to remove air from, or prevent contact of air with, the juices during preparation or bottling, but care was taken to restrict access of air by undue agitation.

Analysis of fresh black currant juices gave :—

Immediately after Milling.		*After 48 Hours Maceration.*	
Specific gravity ..	1.057	Specific gravity ..	1.045.
Total acidity ..	3.45% (as citric acid).	Total acidity ..	3.45% (as citric acid).
Ascorbic acid ..	192.3 mg/100 ml. (calculated from 4.37 ml. N/1000 dye per 0.2. ml.)	Ascorbic acid ..	174.2 mg/100 ml. (calculated from 3.96 ml. N/1000 dye per 0.2 ml.).

The strawberry and black currant samples were stored in the laboratory in a position which afforded the daily alternation of light and darkness. The effect of light and air will be examined and discussed in detail in a later paper.

Results.

The course of the deterioration of antiscorbutic potency, as indicated by ascorbic acid determination, was followed in each of the series of juices and syrups by periodical titrations with indophenol over the course of more than a year. A fresh bottle was taken for each estimation. All results are expressed in ml. of $\frac{N}{1000}$ indophenol.

TABLE I.

RATE OF LOSS OF INDOPHENOL REDUCING POWER OF STRAWBERRY JUICES.

(Titrations in ml. of $\frac{N}{1000}$ dye).

Treatment.	Period of storage in days.							Condition of juice after 389 days.	Per cent. of original reducing power remaining after 389 days.
	0	4	11	32	77	189	389		
	ml	ml	ml	ml	ml	ml	ml		
(i) Untreated	5.46	4.70	3.55	1.47	0.55	0.31	—	Fermented; developed mould and bacterial growth* ..	Nil
(ii) 350 p.p.m. SO_2 added	5.46	—	5.15	4.95	4.80	4.58	3.35	Fermented	61.3
(iii) 600 p.p.m. benzoic acid added ..	5.46	4.49	4.42	3.69	3.66	3.05	2.56	Fermented	46.9
(iv) Pasteurised at 160°F. for 30 minutes ..	5.46	3.94	3.74	3.19	2.62	2.62	2.18	Unfermented	40.0
(v) pH adjusted to 2.3 ..	5.46	—	5.30	5.27	5.31	4.81	4.06	Slightly fermented	74.5
(vi) Acidity raised to 2.5% as citric acid ..	5.46	4.75	4.16	4.26	0.65	0.09	—	Fermented; developed mould and bacterial growth ..	Nil

* During the initial few days after preparation, a rapid fermentation developed in the untreated juice and within two or three weeks a slow fermentation had become obvious in all treated juices with the exceptions of those which had been pasteurised or pH controlled.

TABLE II.

RATE OF LOSS OF INDOPHENOL REDUCING POWER OF STRAWBERRY SYRUPS.

(Titrations in ml. $\frac{N}{1000}$ dye).

Syrup Strength.	Treatment.	Period of storage in days.					Condition of syrup after 389 days.	Per cent. of original reducing power remaining after 389 days.
		0	11	77	189	389		
		ml	ml	ml	ml	ml		
A. 50° Brix	(i) Untreated	3.38	3.08	2.39	2.19	1.16	Fermented ..	34.3
	(ii) 350 p.p.m. SO_2 added	3.38	3.41	3.13	2.93	2.85	Unfermented ..	84.2
	(iii) 600 p.p.m. benzoic acid added	3.38	2.98	2.37	2.12	1.55	Unfermented ..	45.7
	(iv) Pasteurised at 160°F. for 30 minutes ..	3.38	2.86	1.87	1.65	1.38	Unfermented ..	40.8
B. 65° Brix	(i) Untreated	2.16	—	1.96	1.81	1.51	Unfermented ..	69.8

TABLE III.

RATE OF LOSS OF INDOPHENOL REDUCING POWER OF BLACK CURRANT JUICES.

(Titrations in ml. $\frac{N}{1000}$ dye.)

Treatment.	Period of storage in days.					Specific gravity after 405 days.	Per cent. of original reducing power remaining after 405 days.
	0	6	48	162	405		
	ml	ml	ml	ml	ml		
(i) Untreated	3.96	3.90	3.75	3.22	2.28	1.015‡	57.8
(ii) 350 p.p.m. SO_2 added	3.96	—	3.71	3.42	2.80	1.015	70.7
(iii) 600 p.p.m. benzoic acid added	3.96	3.75	3.58	3.26	2.47	1.045	62.3
(iv) Pasteurised at 160°F. for 30 mins. ..	3.96	3.86	3.55	3.46	2.52	1.045	63.8
(v) pH adjusted to 2.2	3.96	3.64	3.62	2.62	1.58	1.045	39.9

‡ Although the untreated black currant juice fermented almost from the commencement, the tendency of the other black currant juices to develop fermentation was distinctly less marked than in the case of the less acid strawberry juices, owing presumably to the difference of acidity. The sulphur dioxide treated juice underwent a very slow fermentation after an initial inactive period, but the remaining treatments (iii—v) sufficed to prevent the development of fermentative micro-organisms.

TABLE IV.

RATE OF LOSS OF INDOPHENOL REDUCING POWER OF BLACK CURRANT SYRUPS.

(Titrations in ml. of $\frac{N}{1000}$ dye).

Syrup Strength.	Treatment.	Period of storage in days.				Condition of syrup after 405 days.	Per cent. of original reducing power remaining after 405 days.
		0	48	162	405		
		ml	ml	ml	ml		
A. 50° Brix	(i) Untreated	2.56	2.20	1.84	1.36	Fermented	53.1
	(ii) 350 p.p.m. SO_2 added ..	2.56	2.35	2.32	2.15	Unfermented	84.0
	(iii) 600 p.p.m. benzoic acid added	2.56	2.22	2.00	1.56	Unfermented	60.8
	(iv) Pasteurised at 160°F. for 30 mins.	2.56	2.27	2.07	1.63	Unfermented	63.7
B. 65° Brix	(i) Untreated	1.85	1.84	1.58	1.36	Unfermented	73.6

Discussion.

Effect of Preservatives.

(*a*) *Sulphur dioxide.* The incidence of fermentation in some of the juices under observation makes it difficult for definite conclusions with regard to comparative losses of ascorbic acid to be drawn. The concentration of sulphur dioxide employed in both the strawberry and black currant juices proved insufficient to inhibit fermentation. Since, however, the ultimate extent of fermentation in the sulphured juices was similar to that of the untreated juices there is some justification for making a comparison of relative losses of ascorbic acid. Tables I and III illustrate a marked preservative action by sulphur dioxide towards antiscorbutic potency. The complete loss of reducing power in the untreated strawberry juice was probably due to oxidising principles arising from the growth of moulds and bacteria following the cessation of fermentation ; a similar condition did not appear in the black currant juice and therefore it is not surprising that there was a considerable amount of residual reducing power long after the completion of fermentation.

Tables II and IV again illustrate the striking preservative action of sulphur dioxide towards antiscorbutic potency of strawberry and black currant syrups. Some significance may be attached to the fact that the percentages of the initial indophenol reducing power retained after a lapse of 13 to 14 months in each case are practically identical.

(*b*) *Benzoic acid.* Addition of 600 p.p.m. of benzoic acid to juices and syrups resulted in the eventual losses of indophenol reducing power in excess of those treated with sulphur dioxide, irrespective of the occurrence or non-occurrence of fermentation.

A close examination of the results in Tables I—IV indicates that relatively greater losses of reducing power after 12 months storage are to be found in the strawberry products. Approximately the same losses are obtained both from the juices and syrups for any one fruit.

Effect of Pasteurisation.

The final differences in loss of reducing power between pasteurised and benzoic acid treated products are insufficiently great to require much comment. The greatest divergence of 6.9% in strawberry juice may have been caused by fermentation. Otherwise, the effect of pasteurisation was very similar to that of benzoic acid.

Effect of Acidity and pH.

By increasing the total acidity of strawberry juice with citric acid from 0.91% to 2.5% the rate of loss of indophenol reducing power was merely temporarily diminished.

The addition of hydrochloric acid to strawberry juice to give a final concentration of 0.4% of this acid to move the pH towards the optimum value for Vitamin C, viz., 2.2.—2.3, was unique in that 74.5% of the original reducing power was retained after 389 days.

Inconsistent results were obtained by similarly adjusting the pH of black currant juice to 2.2. The rapid falling off of reducing power after a lapse of 2 months was explained by an examination of the pH at a later date. By some unknown means it had reverted to about pH5.0, although the initial concentration of hydrochloric acid had been comparatively large, viz., 0.9%.

Effect of 65% Sugar.

In both cases the heavy syrups of strawberry and black currant retained about 70% of their original indophenol reducing power after 12 to 13 months of storage. This figure is inferior to that resulting from sulphur dioxide treatment but well above those of other treatments, and therefore high sugar concentration, sufficient to inhibit fermentation, exerts a valuable preservative effect.

A review of the evidence presented in this paper is suggestive of the importance of sulphur dioxide as a means of preserving anti-scorbutic potency, or Vitamin C, in fruit juices and syrups of the strawberry and black currant type. That this beneficial effect does not apply to citrus juices has been repeatedly demonstrated by previous investigators, although the author has not yet attempted to seek confirmation in this laboratory. However, any question as to the harmful effect of sulphur dioxide on antiscorbutic potency may now be excluded from the above-mentioned products in the light of the present work. The preservative effect of sulphur dioxide on the antiscorbutic potency of strawberry and black currant syrups may be intensified by the fact that a considerable proportion of the sulphur dioxide present becomes "fixed," whereas most of the sulphur dioxide added to juices alone, remains in a "free" state.

The presence of dissolved air in all the samples under examination was probably a major factor contributing to the loss of anti-scorbutic potency. Totally different results might have been obtained if air had been excluded, but since de-aeration of these

products is not a common commercial practice, the value of these experiments is in no way impaired.

Summary.

1. A method for the determination of indophenol reducing power of English soft fruit juices and syrups containing sulphur dioxide is described.

2. Fresh juices of strawberry and black currant were treated and bottled as follows :—

(i) Untreated.

(ii) 350 p.p.m. sulphur dioxide added.

(iii) 600 p.p.m. benzoic acid added.

(iv) Pasteurised at 160°F. for 30 minutes.

A similar series of syrups of 50° Brix strength and an untreated portion of 65° Brix strength were also prepared.

The rate of loss of indophenol reducing power was followed in each treatment over a period of 13 to 14 months of storage.

3. Sulphur dioxide exerted the greatest preservative action on antiscorbutic potency.

4. The effects of benzoic acid and pasteurisation were very similar and afforded no definite preservative action on antiscorbutic potency.

5. High sugar concentration exerted a preservative effect on antiscorbutic potency, but less than that of sulphur dioxide.

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ANIMAL HEALTH IN WAR TIME.

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The struggle between health and disease is no less severe among animals than among the human race. In the latter case, civilisation has built up health safeguards through hygiene and sanitation which are never likely to be approximated by our domesticated animals. Measures, of course, do exist which minimise the risk of widespread outbreaks of animal diseases which are of a deadly nature and they are incorporated in the acts and orders relating to diseases of animals. Statistics concerning the incidence of these diseases are available from the time the essential safeguards became a legal obligation, but apart from these scheduled diseases there are many other conditions which cause loss among livestock concerning which no exact figures are available and, while the percentage incidence on any one farm may be very low, the aggregate loss to the farming industry must be colossal. Many of these conditions are preventable or can be cured if treatment is undertaken early enough, so that the best defence against them is a keen sense of observation and an early diagnosis of the illness.

The conditions encountered in the veterinary laboratory during the year ending September 30th, 1939, when over 600 pathological specimens were submitted for examination, were little different from those seen in former years. The diseases met with were mainly of fairly common occurrence, but it cannot be claimed that all the animals submitted died from simple disorders which were easily diagnosed and just as easily prevented or cured. The fact emerges, however, that a large proportion of the losses of animals experienced by farmers are due to diseases or conditions known to science for many years, but that there may be many manifestations of the same disease, and complications may arise which completely mask what are regarded as the typical symptoms of a particular disease. It is rarely possible to find a sick animal which shows symptoms identical with those described in the text books as being characteristic of any one disease, nor is it possible to eliminate the presence of a disease if an unusual symptom is present. This point is worthy of emphasis, as what farmers may regard as a " chill "

in an animal may in actual fact be the red lamp warning him of an impending outbreak of disease.

Infections due to bacteria are often insidious in their onset, and cause heavy loss, particularly among cattle, where we have such diseases as Tuberculosis, Contagious Abortion, Mastitis and Johne's Disease. By painstaking efforts, many farmers have been able to control these scourges and eradicate them from their herds, but unfortunately herds entirely free from these diseases are the exception rather than the rule. Sheep are fairly free as compared with cattle from infections due to micro-organisms, although Lamb Dysentery, which occurs in the Bristol Province, has caused a very high mortality among young lambs. This disease is fortunately readily controlled by the inoculation of anti-serum into the newly-born lamb, and several outbreaks were controlled last spring by its timely administration. In the case of the pig, Swine Fever takes a heavy toll, and in this respect is closely followed by Erysipelas and Paratyphoid.

Internal parasites are responsible for much more damage than is usually credited to them, the chief offenders being the stomach worms and the liver fluke in both sheep and cattle. The liver fluke varies in numbers in direct proportion to the numbers of the fresh water snail which is its intermediate host, so that the incidence of the disease varies from year to year. With the wet summer which we have just had in 1939 we may anticipate a greater incidence of fluke disease in the spring of 1940, unless extensive preventive dosing of sheep flocks has been carried out. The fact that a severe outbreak caused by numerous immature flukes has already been encountered in this area supports this view. The ravages wrought by stomach worms are known all over the world where sheep farming is practised. Outbreaks of disease among young cattle due to these worms are also becoming increasingly common. As these parasites spend a part of their life on the field, the greater the animal population per acre, the greater the number of worms per acre, and consequently per animal, until the point is reached where the animal cannot support such a worm burden. This process was observed by farmers many years ago, and such land became known as " sheep sick."

Expansion of the sheep farming industry will no doubt take place during this war, and the ever-present danger will be the stomach worms. To offset the danger of heavily sheeped pastures, there will be many more acres of arable crops and, if these are properly folded, the worms in the sheep will be reduced and the pastures rested. The most widely adopted weapon will no doubt be

the worm drench, used not so much as a cure but as a preventive. The drugs used act directly on the worms in the animals, and thus also reduce the numbers of worm eggs reaching the pastures. In this respect new drugs are being constantly tried out and at the present time a drug which shows exceptional promise in removing the different species of worms is being tested on sheep flocks all over the country. If the efficacy found experimentally is maintained in the field, farmers will be able to take full measure of grazing from pastures of enhanced fertility.

While no-one can foresee exactly what changes our existing animal husbandry will undergo, there appears at present to be a tendency to return to thoroughly mixed farming. From a disease prevention view-point, the more varied the types of livestock, the less likelihood is there of disease outbreaks, and even if disease does occur, it can invariably be restricted to the one type of animal. The serious nature of epizootic diseases can never be taken lightly, but all the available information points to the conclusion that farmers need not anticipate any greater incidence of disease among our livestock under the altered farming conditions.

THE CARE OF MILK IN WAR TIME.

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Now that we are at war, the first consideration of the milk producer is to maintain as far as possible the country's milk yield. At the same time, however, it is equally important that the same precautions should be taken to safeguard the quality as in time of peace.

The health of the nation must be protected. The removal of a large proportion of the population from vulnerable cities to rural areas results in a larger volume of untreated raw milk being consumed, hence the necessity for all such milk to be free from germs capable of causing disease. Thus the health of the dairy stock and dairy workers, and the system of milk production adopted on the farm remains, more than ever, a constant responsibility of the milk producer.

Again, because of the demand for economy, transport facilities are now reduced, and the delivery of milk to the wholesaler, factory, or consumer may be considerably delayed. Such delay serves to increase the rate of deterioration in quality due to the inevitable growth of bacteria.

Yet another aspect which now assumes great importance is the manufacture of essential dairy products within the country. Good wholesome milk is an equal necessity for the manufacture of products, such as butter and cheese, as it is for the liquid trade.

From what has been said already, it is evident that, in spite of difficulties on all sides, the milk producer is urged to do his utmost to ensure that the quality of market milk is maintained. The majority of faults which may develop in milk, or in butter and cheese during and after manufacture, are very often traceable to bacteria which have gained access to the milk on the farm. Therefore, a brief review of the major causes of bacterial contamination, and the practical control measures to be adopted is now opportune. It must be remembered, however, that many minor sources of bacterial contamination exist, but if the producer can successfully control the major causes, serious deterioration in the quality of milk need not be feared.

Causes of Bacteriological Contamination of Milk and their Control.

What are the major causes of bacterial contamination of milk ? During the past year more than 700 milk samples of an advisory nature have been examined by the Advisory Dairy Bacteriologist. The majority of these samples were submitted from farms, in the Bristol Province, where difficulty was being experienced in the production of milk of satisfactory bacteriological standard.

Reliable data concerning the methods of production practised on some farms were not obtainable, but, in the case of the others, the chief factors causing trouble were, in order of importance, the use of dairy equipment which was bacteriologically unclean, poor cooling of the milk, the incidence of Mastitis, and inferior grooming and cleansing of the cows.

From the data obtained, contaminated dairy equipment was the cause of the poor quality milk in at least 60% of the cases recorded. In these instances, often the fundamental point in obtaining physically clean utensils, namely by thorough rinsing in cold water immediately after milking, was obviously not given due attention.

Unless the preliminary rinse is given, milk adhering to the surface of utensils dries and forms a scale which harbours bacteria and acts as a shield for them during the subsequent washing and sterilizing processes. In this connection, milking machines need special attention, pipe-lines require liberal flushing with water, and brushes should always be used for cleaning teat-cup liners and connections.

Again, in many instances, the sterilization treatment was ineffective because of failure to subject all the equipment with which the milk comes in contact to a temperature of 210°F. for 10 minutes. Here again, because of the relative difficulty of washing milking machines, more importance is attached to effective sterilization.

The adoption of clean production methods is, to some extent, wasted energy unless the milk is subsequently cooled effectively.

It has been found in practice that the best possible use is not always—in fact, rarely—made of the available cooling water supply on the farm. There is too great a margin between the temperature of the water and that of the cooled milk ; in some cases investigated the margin was 10°F. or more ! If the rate of flow of milk over the cooler is adjusted properly, there should be no difficulty in cooling milk to within 3°F. of the temperature of the water entering the cooler.

It is not always realized that only a very small quantity of mastitis-infected milk need be added to the bulk to cause the whole to become sour or tainted before it reaches the wholesaler, factory, or consumer, especially in periods of warm weather. Yet this is a fact which must be constantly borne in mind.

Control of Mastitis rests largely with the cowman. Regular and careful examination of the fore-milk of each cow for the presence of clots, flakes or discoloured milk, which symptoms are indicative of udder inflammation, results in the disease being diagnosed in its early stages. The periodical use of brom cresol papers on the farm has been found to be extremely useful in revealing cases where the disease is present in the latent form, *i.e.* when no clots or flakes are visible. When in doubt samples of milk should be submitted to a laboratory for bacteriological examination.

Affected and suspected cows should be milked last to avoid conveying the disease to healthy cows *via* milkers' hands or by the milking machine. Discharge from affected quarters should never be drawn on to the cowshed floor for the same reason.

Contamination from the cow's body, in the form of particles of manure, dust and hairs, can be serious unless general grooming, and the washing of flanks, hindquarters and udder are conducted conscientiously. In practice such operations may not be easy when they have to be accomplished in restricted light, but it is well to remember that the periodical removal of long hair from the udder, flanks, hindquarters and tail renders grooming and cleaning much less arduous.

Modern dairy equipment will only produce the best results when skilled labour is available to use it intelligently. Unfortunately, skilled dairy workers are scarce, and farmers are compelled to employ labour with no knowledge of clean milk production. Whenever untrained workers have to be employed for responsible duties in the dairy, they should be taught the correct methods of clean milk production at the outset, that is, before they have acquired the wrong methods by force of habit.

Lastly, the value of small monetary bonus payments to dairy workers, based on the bacteriological results of milk samples, has been amply proved, so much so that this form of inducement to workers to produce a satisfactory article consistently is strongly recommended, particularly where farmers are unable to give their personal attention to the management of the dairy.

HOW THE WAR MAY AFFECT PRODUCTION COSTS.

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For a number of years the Economics Section has been compiling statistics relating to farm costs and production so that there now exists a valuable amount of data giving the trend of farm productivity in the five counties around Bristol. It was realized immediately at the outbreak of war that, with interruptions in farmers' supplies, both costs and output would suffer so that it was all the more important that the series of statistics commenced in peace time should be continued during hostilities. But more than that, for although the general scheme of work is being continued, certain inquiries are being intensified. In particular, a considerably greater amount of detail is being collected upon quantities and qualities of feeding stuffs, and upon the labour position. Price movements are being carefully tabulated so that the additional burden thrown upon farmers can be calculated with a considerable degree of accuracy. Recently, for instance, a great deal has been heard about the increased cost of producing milk. Individual farmers may have their own estimate of such an increase, but it is the task of the Economics Section to obtain weekly records of such facts from a number of farms and, while noting the variations between farm and farm, to calculate the average difference in cost over a wide area.

Obviously such data could not be compiled except for the willing co-operation of those farmers who keep the necessary records or give the Department access to their farm accounts. It should be recognized that such farmers are performing a service for the whole of the farming community.

In the case of milk production for instance it has been possible to calculate the following items of cost on 55 farms for the four years 1935 to 1938. The figures for 1939 are not yet complete.

ITEMS OF COST PER GALLON.

ITEM.	*Averages over 55 Herds. Year ending* Sept. 1935.	Sept. 1936.	Sept. 1937.	Sept. 1938.
	d.	*d.*	*d.*	*d.*
Foodstuffs	5.7	5.1	5.5	6.1
Labour	2.4	2.3	2.4	2.5
Herd Depreciation	1.0	1.0	0.1	1.2
Miscellaneous	1.6	1.5	1.6	1.6
	10.7	9.9	9.6	11.4
Subtract Credits	0.8	0.8	0.9	0.9
Final Cost	9.9	9.1	8.7	10.5

Of the five items, three are relatively stable from year to year, labour, miscellaneous, and credits, although the progress of the war will undoubtedly make a considerable difference, but probably not so great as that which will occur in the items of foodstuffs and herd depreciation.

In the four years, labour cost has risen slightly, from 2.3d. to 2.5d. per gallon. The figures include family labour priced at comparable rates, and refer only to labour directly associated with the herd, such as moving cows, milking, cleaning, sterilizing, and similar operations. Labour on pastures is included under foodstuffs.

Miscellaneous costs amount to 1½d. per gallon and include repairs, depreciation and small equipment for the cowshed and dairy; veterinary bills and medicines; bull costs and service fees; milking machine costs where these arise, and a charge for general farm overheads such as telephone bills.

Credits average between ¾d. and 1d. per gallon. They include, firstly, income from calves reckoned at 4 days old, whether sold or kept on the farm for rearing, and secondly, manurial residues based on the quantities of concentrates and fodders recorded as fed to cows. These items are, of course, subtracted from costs.

The cost entered for foodstuffs covers concentrates, hay and straw, roots and greens, and grazing, whether purchased or home-grown. Where foodstuffs are grown on the farm they have been priced in accordance with the Ministry of Agriculture's farm feeding values. These feeding values rise and fall as the market prices of certain cakes and meals rise and fall. Grazing has, however, been costed, and it is here that a portion of the farm rent enters the costs. Foodstuffs cost has increased by 1d. per gallon between 1936 and 1938, and in the year ending September 1938

was a fraction over 6d. per gallon. This will have risen still more in 1939 and the shortage of supplies during the war will send up the cost still higher.

Herd depreciation takes into account the purchase of cows for the herd and the sales of cows from the herd. In the case of reared stock transferred into the herd, the valuation is allowed to move in sympathy with current market values. At the close of each costing year the herd is valued and movements in market values once again taken into consideration. The figure for herd depreciation is the balance struck after all these elements have been considered.

In the year 1937, herd depreciation almost disappeared. This was due to the rise in the market value of cows. The fall in total cost per gallon shown for the third year of the scheme is entirely accounted for in this way, but the fall of 1d. per gallon in herd depreciation was partly offset by a rise of ½d. per gallon in food cost. The influence of the war will be to raise market prices of cows to a fairly high figure, with the result that depreciation may be converted into appreciation.

The whole question of milk costs is naturally linked up with the size and type of farm upon which the milk is produced. Space does not permit a detailed analysis to be made of the many and wide variations in cost as between farm and farm, but these variations are persistent from year to year. It is possible to state that whatever farm commodity be costed, there will always be found these considerable divergencies from the average cost. The statement can be put still more broadly, for if one takes a group of farms of similar acreage the total farm expenditure on these farms will also vary within wide limits. For example, 201 farm expenditures were examined for the year 1938, the farms having been grouped according to size. The following table gives the average expenditure for each size group and the range of expenditure found on farms within a particular size-group.

Size Group. *Acres.*	*No. of Farms.*	Expenditure. *Total.* £	*Average Per Acre.* £	*Range Per Acre.* £ £
50— 100	34	41,302	16	9—51
100— 200	52	96,329	12	5—31
200— 300	49	156,102	13	7—32
300— 500	34	142,925	11	5—25
500—1000	24	125,690	8	4—19
1000	8	68,684	6	4— 9
	201	631,032	10	– –

Thus a total expenditure of nearly two-thirds of a million pounds works out at an average of £10 per acre over all the 201 farms combined. By size group there is a fall in expenditure from £16 to £6 per acre as the average size of farm increases. In all size groups there is a very considerable range in farm expenditures; a great deal naturally depends upon the type of farming and the dependence of livestock upon purchased feeding stuffs; pigs greatly influence total expenditure.

Examination of the range in farm incomes, or of the constituent items of both expenditure and income yields a great deal of interesting and useful information. It will be part of the work of the Economics Section to carry out such analyses during the war to ascertain in what directions and to what extent farm expenditures and incomes are being modified.

THE NECESSITY FOR SOIL ANALYSIS IN WAR TIME.

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Farming is essentially a complex business, and the successful farmer must possess the ability to test, adapt and utilize every element, whether old or new, in the realm of agricultural knowledge. Obviously, the most valuable asset in the farmer's possession is the fertility of his soil, for upon this depends to a great degree the productivity of the farm. Any system of farming that fails to maintain soil fertility must be regarded as unsatisfactory, and the farmer must use every means to implement the productive capacity of his soil.

Soil fertility is so complex that it has been long realized that no farmer can hope to understand every aspect of the problem, and it is for this reason that there has been in operation for some years a scheme whereby free advice is available to farmers regarding soil fertility. In view of the present emergency, with its demand for the highest productivity from every acre, together with the changes which are bound to occur in the agricultural systems employed, it seems necessary to indicate the contribution soil analysis can make to ensure that farmers will utilize the soil and the valuable nutrients contained therein to the best possible advantage.

In this connection it may be pertinent to consider some of the results obtained from a soil survey which has been carried out in the Bristol Province since October 1938. Areas were selected in various counties in the Province covering a total area of over 40,000 acres, and soil samples were taken in a systematic manner, together with a field to field survey of the fertility conditions in the areas concerned. An examination of the lime status of some 3,000 soil samples showed that of those taken from areas where the soil-forming rocks are non-calcareous, 37% showed indications of extreme acidity, whilst another 37% were sufficiently acid to suggest that acidity was a factor in retarding plant growth. Only 25% could be considered to have a lime status which was in any way satisfactory.

An examination of the same data reveals that 31% of these soils are seriously deficient in phosphate. 46% indicate that, whilst

perhaps not deficient, they are working on a very minimum reserve of nutrient. Again, only 23% can be regarded as having a phosphate status adequate for all conditions of crop production. A similar examination of the data for potash again shows that 43% of the soils examined are sufficiently depleted of this nutrient to suggest that potash deficiency is an adverse factor in attempts to obtain maximum plant growth.

These figures alone suffice to suggest that there is still a great need for farmers to know more of the character of the soil which they so constantly utilize, and that their knowledge of the nutrient status of their soils is not as complete as it should be. At this point, therefore, it may be of interest to state exactly what benefit the farmer can derive from having his soil analysed, and how far the knowledge so gained will enable him to satisfy the nutrient requirements of different crops.

How Soil Analyses Help the Farmer.

Of the various elements taken in by the plant from the soil, most farmers are aware that deficiencies only generally occur in nitrogen, phosphate, potash and lime.

To consider first the question of lime. Not only is it a necessary constituent of crops, but it is also important for the influence it exerts on the physical condition of the soil, for its action in reducing soil acidity, and for the part it plays in connection with the biological changes which take place in the soil.

Excessive soil acidity is well known to be harmful because it reduces crop growth, interferes with the full action of soil micro-organisms, often promotes disease organisms and even sets up conditions where weed growth may increase. It is now well known that there is an optimum range of acidity or alkalinity for each kind of crop, and that soils need not be neutral or slightly alkaline to ensure full crop growth. There are certain crops, in fact, which grow best under slightly acid conditions, and it is important that lime should not be applied indiscriminately, but in relation to the type of crop grown.

The value of soil analysis to a farmer from this aspect is that it is possible to tell exactly how much lime is necessary to create the optimum conditions in the soil, because the degree of acidity may vary within wide limits for different soils and with various crops. The importance, therefore, of controlling soil reaction is fully recognized, and it is now possible in the laboratory to measure with a considerable degree of accuracy the reaction of any portion of the soil.

Every soil contains greater or lesser reserves of phosphate and potash. Much of these, however, are in forms which are not easily available to the plant. This is particularly true of certain types of soils, and it is necessary to consider the individual characteristics of different soils when discussing the need for phosphatic and potassic fertilizers. The total amount of phosphate or potash in a soil is no indication of the quantity available to the plant. It is important to know what percentage of the total of these nutrients may become available to the crops. Numerous methods have been employed for determining the available phosphate and potash, and by means of certain chemical tests, evidence can be obtained which, when considered in relation to the particular soil type, will tell whether a particular soil is deficient in either of these nutrients.

When a farmer sends a soil sample to the laboratory, it is possible by means of these tests to tell him whether his soil needs lime, phosphate or potash, and thereby prevent a waste of valuable materials. Moreover, the information so derived enables the analyst to set up standards for the comparison of soils. Such standards cannot be applied in the case of all soils and under all conditions, but by taking into account the individual characteristics of the different soils it is possible to suggest when the content of available phosphate and potash is adequate. Soil analysis, therefore, provides a general survey of the fertilizer requirements of various types of soils, and enables the farmer to improve his methods of manuring in accordance with the particular demands of soils and crops.

How to Take a Soil Sample for Analysis.

The value of a soil analysis is dependent on the manner in which the soil sample has been taken, and it is therefore necessary to take samples in a special way. Sampling may be done in the following manner :—

Before commencing sampling operations go over the field carefully, note any variations between different parts of the field and decide where to take samples for the special purpose in view. Then take a clean spade (free from dirt and rust) and cut a hole with a sloping side one spade width and place a sheet of clean paper or sacking in the bottom of the hole. Cut a slice about 1 inch thick down one side of the hole and throw the soil on to the paper or sacking. Gather the sample, place it in a clean container, such as a bucket or bag, and proceed in a similar manner until a sufficient number of slices have been taken.

Mix the slices thoroughly together on a bench and separate at random about 4 lb. of the soil. Place this in a clean, strong box, bag or tin for transit to the Laboratory.

It is usual to take samples to a depth of 9 inches, but where, as is often the case, the depth of soil is less than this, only sample to the ploughing depth. No general rule can be given for the number of slices taken from any one field, but if slices are taken along lines crossing a field in a diagonal direction then take one or two slices per acre.

The larger and more uniform the field, the fewer slices per acre will be required ; and the smaller the field the greater the number of slices necessary per acre. Thus, in the case of a 4-acre field, seven to nine slices may be taken, whereas in a 30-acre field twenty-five to thirty slices may suffice for the whole field. The important point is to obtain as far as possible complete representation of the soil conditions in the particular area. When different parts of the same field exhibit differences in fertility, or special sections have given crop failures, separate samples should be taken from each unit, and special labels attached to each.

In sending each sample, the following information should be given :—

(1) Nature of subsoil.
(2) Whether drainage good, and whether natural or artificial.
(3) Texture of soil, that is, heavy or light.
(4) Previous cropping during the last 4 years.
(5) Future cropping.
(6) Previous manuring during last 4 or 5 years.
(7) When limed last.
(8) Whether any failures or difficulties experienced.
(9) Name and address of farm, together with the name of field from which each sample is taken.

Farmers in the Bristol Province, comprising the counties of Gloucester, Hereford, Somerset, Wiltshire and Worcester, should address samples, carriage paid, as follows :—

In the case of Agricultural Soils :

The Agricultural Advisory Office,
University of Bristol,
22, Berkeley Square,
Bristol, 8.

In the case of Horticultural Soils, from Market Gardens, Glasshouses, Gardens and Allotments, etc. :

The Research Station,
Long Ashton,
Bristol.

REPORT ON ADVISORY WORK, 1938-1939.

The period covered by the Report includes September 1939, the first month of the war, when advisory activities were abnormal, the main effect being a pronounced slowing down of normal seasonal enquiries due to the change over to war-time conditions on farms. Otherwise the advisory activities within the Department were comparable with those of previous years and work proceeded along similar lines.

In view of the war-time conditions, the present Report is presented in the form of a general summary only and the usual sectional reports are omitted. A table of statistics is included to enable the volume of work to be compared with that of previous years.

The number of enquiries shown in the statistics for 1939, which are directly comparable with 1938, shows an increase of 809 in a record total of 7,716. It should be noted in making the comparison of totals in the table of statistics that those for Willow Growing are not included in the 1939 total, and thus 325 must be substracted from the 1938 total to obtain a direct comparison.

The increase is again almost wholly due to large increases in Agriculture and Agricultural Chemistry (+856) and Dairy Bacteriology (+296). In the former of these the large expansion of work is to be attributed to special developments under the Land Fertility Scheme.

As in previous years no statistics are included for Agricultural Economics, but work in that Section continues to expand, and since the outbreak of war the staff has been required to take over special costing schemes for the Ministry of Agriculture and Fisheries. Willow Growing statistics are not included owing to the termination of Mr. Hutchinson's appointment as Willow Officer on July 31st, on reaching the age limit, no successor having been so far appointed. In the case of Poultry Pathology statistics refer only to cases in which the officer has assisted with enquiries of the Veterinary Adviser. Under the Poultry Pathology Scheme large increases are shown for both Blood Tests and Post-Mortem Examinations, the totals of 85,626 and 2,894 comparing with those of 50,093 and 1,762 in 1938.

The statistics in the table refer to thirteen subjects, four at Berkeley Square Centre and nine at Long Ashton.

The nett increases or decreases for the various subjects at the two centres are as follows :—

Berkeley Square. Total increase 1,178 ; Agriculture and Agricultural Chemistry (+856) ; Dairy Bacteriology (+296) ; Veterinary Science (—56) ; Poultry Pathology (+82).

Long Ashton. Total decrease 369 ; Cider (—55) ; Cider Instruction (—38) ; Fruit Products (+24) ; Pomology (—150) ; Horticultural Chemistry (— 16) ; Economic Entomology (—65) ; Economic Mycology (—56) ; Insecticides and Fungicides (—85) ; Domestic Preservation (+72).

Apart from Agriculture and Agricultural Chemistry and Dairy Bacteriology the changes may be regarded as normal fluctuations.

At the Berkeley Square Centre the survey work under the Land Fertility Scheme has continued to increase the contacts between the Department and farmers in poorer soil areas of the Province.

The counties of Dorset, Monmouth and Worcester again participated in the Cider Instruction Scheme and Special Orchard Surveys in these counties were continued.

The Plant Pathologists at Long Ashton continued their Spray Programme Service to Fruit Growers throughout the Province.

Since the retirement of Mr. Hutchinson, the Willow Officer, on July 31st. 1939, advisory work on willows has been restricted to pest and disease control, pending the decision of the Ministry of Agriculture regarding the continuation of the willow work.

The Advisory work during the year covered the following subjects :—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Fruit Products, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables. Willow Growing was also included until July 31st, 1939.

The numbers of enquiries submitted to the Department during the past six seasons, excluding Willow Growing for the year ending September 1939, are summarised in the following table :—

	Year ending September 30th.					
	1934	1935	1936	1937	1938	1939
Gloucester (including Bristol) ..	945	1602	1622	1730	1775	2264
Hereford	337	360	497	275	337	556
Somerset	997	1119	1138	1118	1459	1117
Wiltshire	476	1365	848	1007	1328	1586
Worcester	496	528	509	360	520	677
Other Areas	1562	1571	1872	1963	1813	1516
	4813	6545	6486	6453	7232	7716

The figures are shown separately in the table for the five counties which comprise the Bristol Advisory Province and for Other Areas. The latter category includes Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and Dorset which participates in the Cider Advisory Scheme.

Staff Changes and Appointments.

Mr. W. R. Muir, B.Sc., Research Assistant in Agricultural Chemistry, resigned his appointment as from March 31st, 1939, on being appointed Bio-Chemist at the Royal Veterinary College, Camden Town. The vacancy thus created was filled by the appointment of Mr. E. L. Smith, B.Sc., (London).

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